AN

HISTORY

OF THE

EARTH,

AND

ANIMATED NATURE.

BY OLIVER GOLDSMITH.

IN EIGHT VOLUMES.

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PREFACE.

NATURAL HISTORY, conſidered in its utmoſt extent, comprehends two objects. Firſt, that of diſcovering, aſcertaining, and naming all the various productions of nature. Secondly, that of deſcribing the properties, manners, and relations, which they bear to us, and to each other. The firſt, which is the moſt difficult part of this ſcience, is ſyſtematical, dry, mechanical, and incomplete. The ſecond is more amuſing, exhibits new pictures to the imagination, and improves our reliſh for exiſtence, by widening the proſpect of nature around us.

Both, however, are neceſſary to thoſe who would underſtand this pleaſing ſcience, in its utmoſt extent. The firſt care of every enquirer, no doubt, ſhould be, to ſee, to viſit, and examine every object, before he pretends to inſpect its habitudes or its hiſtory. From ſeeing and obſerving the thing itſelf, he is moſt naturally led to ſpeculate upon its uſes, its delights, or its inconveniences.

Numberleſs obſtructions, however, are found in this part of his purſuit, that fruſtrate his diligence and retard his curioſity. The objects in nature are ſo many, and even thoſe of the ſame kind are exhibited in ſuch a variety of forms, that the enquirer finds himſelf loſt, in the exuberance before him, and, like a man who attempts to count the ſtars unaſſiſted by art, his powers are all diſtracted in the barren ſuperfluity.

To remedy this embarraſſment, artificial ſyſtems have been deviſed, which

grouping into maſſes thoſe parts of nature more nearly reſembling each other, refer the enquirer for the name of the ſingle object he deſires to know, to ſome one of thoſe general diſtributions, where it is to be found by further examination.

If, for inſtance, a man ſhould, in his walks, meet with an animal, the name, and conſequently the hiſtory of which, he deſires to know, he is taught by ſyſtematic writers of natural hiſtory to examine its moſt obvious qualities, whether a quadrupede, a bird, a fiſh, or an inſect. Having determined it, for explanation ſake, to be an inſect, he examines whether it has wings; if he finds it poſſeſſed of theſe, he is taught to examine whether it has two or four; if poſſeſſed of four, he is taught to obſerve, whether the two upper wings are of a ſhelly hardneſs, and ſerve as caſes to thoſe under them; if he finds the wings compoſed in this manner, he is then

taught to pronounce, that this infect is one of the beetle kind: of the beetle kind, there are three different claffes, diftinguifhed from each other by their feelers; he examines the infect before him, and finds that the feelers are clavated or knobbed at the ends; of beetles, with feelers thus formed, there are ten kinds; and among thofe, he is taught to look for the precife name of that which is before him. If, for inftance, the knob be divided at the ends, and the belly be ftreaked with white, it is no other than the Dor or the May-bug; an animal, the noxious qualities of which give it a very diftinguifhed rank in the hiftory of the infect creation. In this manner a fyftem of natural hiftory may, in fome meafure, be compared to a dictionary of words. Both are folely intended to explain the names of things; but with this difference, that in the dictionary of words we are led from the name of the thing to its definition;

whereas in the ſyſtem of natural hiſtory, we are led from the definition to find out the name.

Such are the efforts of writers, who have compoſed their works with great labour and ingenuity, to direct the learner in his progreſs through nature, and to inform him of the name of every animal, plant, or foſſil ſubſtance, that he happens to meet with; but it would be only deceiving the reader, to conceal the truth, which is, that books alone can never teach him this art in perfection; and the ſolitary ſtudent can never ſucceed. Without a maſter, and a previous knowledge of many of the objects in nature, his book will only ſerve to confound and diſguſt him. Few of the individual plants or animals, that he may happen to meet with, are in that preciſe ſtate of health, or that exact period of vegetation, from whence their deſcriptions were taken. Perhaps he meets the plant only with leaves, but the ſyſtematic writer has deſcribed it in flower. Per-

haps he meets the bird before it has moulted its firſt feathers, while the ſyſtematic deſcription was made in its ſtate of full perfection. He thus ranges without an inſtructor, confuſed and with ſickening curioſity from ſubject to ſubject, till at laſt he gives up the purſuit, in the multiplicity of his diſappointments.

Some practice, therefore, much inſtruction and diligent reading, are requiſite to make a ready and expert naturaliſt, who ſhall be able, even by the help of a ſyſtem, to find out the name of every object he meets with. But when this tedious, though requiſite part of ſtudy is attained, nothing but delight and variety attend the reſt of his journey. Wherever he travels, like a man in a country where he has many friends, he meets with nothing but acquaintances and allurements in all the ſtages of his way. The mere uninformed ſpectator paſſes on in gloomy ſolitude; but the naturaliſt,

in every plant, in every inſect, and every pebble, finds ſomething to entertain his curioſity, and excite his ſpeculation.

From hence it appears, that a ſyſtem may be conſidered as a dictionary in the ſtudy of nature. The ancients, however, who have all written moſt delightfully on this ſubject, ſeem entirely to have rejected thoſe humble and mechanical helps to ſcience. They contented themſelves with ſeizing upon the great outlines of hiſtory, and paſſing over what was common, as not worth the detail; they only dwelt upon what was new, great, and ſurpriſing, and ſometimes even warmed the imagination at the expence of truth. Such of the moderns as revived this ſcience in Europe undertook the taſk more methodically, though not in a manner ſo pleaſing. Aldrovandus, Geſner, and Johnſon, ſeemed deſirous of uniting the entertaining and rich deſcriptions of the ancients with the dry and ſyſ-

tematic arrangement, of which they were the firſt projectors. This attempt, however, was extremely imperfect, as the great variety of nature was, as yet, but very inadequately known. Neverthelefs, by attempting to carry on both objects at once; firſt, of directing us to the names of the thing; and then, giving the detail of its hiſtory, they drew out their works into a tedious and unreaſonable length; and thus mixing incompatible aims, they have left their labours, rather to be occaſionally conſulted than read with delight by poſterity.

The later moderns, with that good ſenſe which they have carried into every other part of ſcience, have taken a different method in cultivating natural hiſtory. They have been content to give, not only the brevity, but alſo the dry and diſguſting air of a dictionary to their ſyſtems. Ray, Klin, Briſſon, and Linnæus, have had only one aim, that of pointing out the object

in nature, of diſcovering its name, and where it was to be found in thoſe authors that treated of it in a more prolix and ſatisfactory manner. Thus natural hiſtory at preſent is carried on, in two diſtinct and ſeparate channels, the one ſerving to lead us to the thing, the other conveying the hiſtory of the thing, as ſuppoſing it already known.

The following Natural Hiſtory is written, with only ſuch an attention to ſyſtem as ſerves to remove the reader's embarraſſments, and allure him to proceed. It can make no pretenſions in directing him to the name of every object he meets with; that belongs to works of a very different kind, and written with very different aims. It will fully anſwer my deſign, if the reader, being already poſſeſſed of the name of any animal, ſhall find here a ſhort, though ſatisfactory hiſtory of its habitudes, its ſubſiſtence, its manners, its friendſhips and hoſtilities.

My aim has been to carry on just as much method, as was sufficient to shorten my descriptions by generalizing them, and never to follow order where the art of writing, which is but another name for good sense, informed me that it would only contribute to the reader's embarrassment.

Still, however, the reader will perceive, that I have formed a kind of system in the history of every part of animated nature, directing myself by the great obvious distinctions that she herself seems to have made, which, though too few to point exactly to the name, are yet sufficient to illuminate the subject, and remove the reader's perplexity. Mr. Buffon, indeed, who has brought greater talents to this part of learning than any other man, has almost entirely rejected method in classing quadrupedes. This, with great deference to such a character, appears to me running into the opposite

extreme; and, as ſome moderns have of late ſpent much time, great pains, and ſome learning, all to very little purpoſe, in ſyſtematic arrangement, he ſeems ſo much diſguſted by their trifling, but oſtentatious efforts, that he deſcribes his animals, almoſt in the order they happen to come before him. This want of method ſeems to be a fault: but he can loſe little by a criticiſm which every dull man can make, or by an error in arrangement, from which the dulleſt are the moſt uſually free.

In other reſpects, as far as this able philoſopher has gone, I have taken him for my guide. The warmth of his ſtyle, and the brilliancy of his imagination, are inimitable. Leaving him, therefore, without a rival in theſe, and only availing myſelf of his information, I have been content to deſcribe things in my own way; and though many of the materials are taken from him, yet I have

added, retrenched, and altered as I thought proper. It was my intention at one time, whenever I differed from him, to have mentioned it at the bottom of the page; but this occurred ſo often, that I ſoon found it would look like envy, and might perhaps, convict me of thoſe very errors which I was wanting to lay upon him. I have, therefore, as being every way his debtor, concealed my diſſent, where my opinion was different; but wherever I borrow from him, I take care at the bottom of the page to expreſs my obligations. But though my obligations to this writer are many, they extend but to the ſmalleſt part of the work, as he has hitherto completed only the hiſtory of quadrupedes. I was therefore left to my own reading alone, to make out the hiſtory of birds, fiſhes, and inſects, of which the arrangement was ſo difficult, and the neceſſary information ſo widely diffuſed and ſo obſcurely related when found, that it proved by much the moſt laborious part of the undertaking.

Thus having made uſe of Mr. Buffon's lights in the firſt part of the work, I may, with ſome ſhare of confidence, recommend it to the public. But what ſhall I ſay to that part, where I have been entirely left without his aſſiſtance? As I would affect neither modeſty nor confidence, it will be ſufficient to ſay, that my reading upon this part of the ſubject has been very extenſive; and that I have taxed my ſcanty circumſtances in procuring books which are on this ſubject, of all others, the moſt expenſive.

In conſequence of this induſtry, I here offer a work to the public, of a kind, which has never been attempted in ours, or any other modern language, that I kown of. The ancients, indeed, and Pliny in particular, have anticipated me, in the preſent manner of treating natural hiſtory. Like thoſe hiſtorians who deſcribe the events of a campaign, they have not condeſcended to give the private particulars of every individual that

formed the army; they were content with characteriſing the generals, and deſcribing their operations, while they left it to meaner hands to carry the muſter-roll. I have followed their manner, rejecting the numerous fables which they adopted, and adding the improvements of the moderns, which are ſo numerous, that they actually make up the bulk of natural hiſtory.

The delight which I found in reading Pliny, firſt inſpired me with the idea of a work of this nature. Having a taſte rather claſſical than ſcientific, and having but little employed myſelf in turning over the dry labours of modern ſyſtem-makers, my earlieſt intention was to tranſlate this agreeable writer, and by the help of a commentary to make my work as amuſing as I could. Let us dignify natural hiſtory never ſo much with the grave appellation of a uſeful ſcience, yet ſtill we muſt confeſs that it

is the occupation of the idle and the ſpeculative, more than of the ambitious part of mankind. My intention was to treat what I then conceived to be an idle ſubject, in an idle manner; and not to hedge round plain and ſimple narratives with hard words, accumulated diſtinctions, oſtentatious learning, and diſquiſitions that produced no conviction. Upon the appearance, however, of Mr. Buffon's work, I dropped my former plan, and adopted the preſent, being convinced by his manner, that the beſt imitation of the ancients was to write from our own feelings, and to imitate nature.

It will be my chief pride, therefore, if this work may be found an innocent amuſement for thoſe who have nothing elſe to employ them, or who require a relaxation from labour. Profeſſed naturaliſts will, no doubt, find it ſuperficial; and yet I ſhould hope that even theſe will diſcover hints, and remarks, gleaned

from various reading, not wholly trite or elementary. I would wish for their approbation. But my chief ambition is to drag up the obscure and gloomy learning of the cell to open inspection; to strip it from its garb of austerity, and to shew the beauties of that form, which only the industrious and the inquisitive have been hitherto permitted to approach.

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AN

AN

HISTORY

OF THE

EARTH.

CHAP. I.

A Sketch of the Universe.

THE world may be considered as one vast mansion, where man has been admitted to enjoy, to admire, and to be grateful. The first desires of savage nature are merely to gratify the importunities of sensual appetite, and to neglect the contemplation of things, barely satisfied with their enjoyment: the beauties of nature, and all the wonders of creation, have but little charms for a being taken up in obviating the wants of the day, and anxious for precarious subsistence.

Philoſophers, therefore, who have teſtified ſuch ſurprize at the want of curioſity in the ignorant, ſeem not to conſider that they are uſually employed in making proviſions of a more important nature; in providing rather for the neceſſities than the amuſements of life. It is not till our more preſſing wants are ſufficiently ſupplied, that we can attend to the calls of curioſity; ſo that in every age ſcientific refinement has been the lateſt effort of human induſtry.

But human curioſity, though at firſt ſlowly excited, being at laſt poſſeſſed of leiſure for indulging its propenſity, becomes one of the greateſt amuſements of life, and gives higher ſatisfactions than what even the ſenſes can afford. A man of this diſpoſition turns all nature into a magnificent theatre, replete with objects of wonder and ſurprize, and fitted up chiefly for his happineſs and entertainment: he induſtriouſly examines all things, from the minuteſt inſect to the moſt finiſhed animal; and, when his limited organs can no longer make the diſquiſition, he ſends out his imagination upon new enquiries.

Nothing, therefore, can be more auguſt and ſtriking than the idea which his reaſon, aided by his imagination, furniſhes of the univerſe

around him. Aſtronomers tell us, that this earth which we inhabit forms but a very minute part in that great aſſemblage of bodies of which the world is compoſed. It is a million of times leſs than the ſun, by which it is enlightened. The planets alſo, which, like it, are ſubordinate to the ſun's influence, exceed the earth a thouſand times in magnitude. Theſe, which were at firſt ſuppoſed to wander in the heavens without any fixed path, and took their name from their apparent deviations, have long been found to perform their circuits with great exactneſs and ſtrict regularity. They have been diſcovered as forming with our earth a ſyſtem of bodies circulating round the ſun, all obedient to one law, and impelled by one common influence.

Modern philoſophy has taught us to believe, that, when the great Author of nature began the work of creation, he choſe to operate by ſecond cauſes; and, that, ſuſpending the conſtant exertion of his power, he endued matter with a quality by which the univerſal œconomy of nature might be continued, without his immediate aſſiſtance. This quality is called *attraction*; a ſort of approximating influence, which all bodies, whether terreſtrial or celeſtial, are found to poſſeſs; and which in all

encreaſes as the quantity of matter in each encreaſes. The ſun, by far the greateſt body in our ſyſtem, is, of conſequence, poſſeſſed of much the greateſt ſhare of this attracting power; and all the planets, of which our earth is one, are, of courſe, entirely ſubject to its ſuperior influence. Were this power, therefore, left uncontrolled by any other, the ſun muſt quickly have attracted all the bodies of our celeſtial ſyſtem to itſelf; but it is equably counteracted by another power of equal efficacy; namely, a progreſſive force which each planet received when it was impelled forward, by the divine architect, upon its firſt formation. The heavenly bodies of our ſyſtem being thus acted upon by two oppoſing powers; namely, by that of *attraction*, which draws them towards the ſun; and that of *impulſion*, which drives them ſtrait forward into the great void of ſpace; they purſue a track between theſe contrary directions; and each, like a ſtone whirled about in a ſling, obeying two oppoſite forces, circulates round its great centre of heat and motion.

In this manner, therefore, is the harmony of our planetary ſyſtem preſerved. The ſun, in the midſt, gives heat, and light, and circular motion to the planets which ſurround it: Mercury, Venus, the Earth, Mars, Jupiter,

and Saturn, perform their conſtant circuits at different diſtances, each taking up a time to complete its revolutions proportioned to the greatneſs of the circle which it is to deſcribe. The leſſer planets alſo, which are attendants upon ſome of the greater, are ſubject to the ſame laws; they circulate with the ſame exactneſs; and are, in the ſame manner, influenced by their reſpective centres of motion.

Beſides thoſe bodies which make a part of our peculiar ſyſtem, and which may be ſaid to reſide within its great circumference; there are others, that frequently come among us, from the moſt diſtant tracts of ſpace, and that ſeem like dangerous intruders upon the beautiful ſimplicity of nature. Theſe are comets, whoſe appearance was once ſo terrible to mankind, the theory of which is better underſtood at preſent: we know that their number is much greater than that of the planets; and that, like theſe, they roll in orbits, in ſome meaſure, obedient to ſolar influence. Aſtronomers have endeavoured to calculate the returning periods of many of them; but experience has not, as yet, confirmed the veracity of their inveſtigations: indeed, who can tell when thoſe wanderers have made their excurſions into other worlds and diſtant ſyſtems, what

obſtacles may be found to oppoſe their progreſs, to accelerate their motions, or retard their return?

But what we have hitherto attempted to ſketch, is but a ſmall part of that great fabric in which the Deity has thought proper to manifeſt his wiſdom and omnipotence. There are multitudes of other bodies diſperſed over the face of the heavens, that lie too remote for examination: theſe have no motion, ſuch as the planets are found to poſſeſs, and are, therefore, called fixed ſtars; and from their extreme brilliancy and their immenſe diſtance, philoſophers have been induced to ſuppoſe them to be ſuns reſembling that which enlivens our ſyſtem; as the imagination alſo, once excited, is ſeldom content to ſtop, it has furniſhed each with an attendant ſyſtem of planets belonging to itſelf, and has even induced ſome to deplore the fate of thoſe ſyſtems, whoſe imagined ſuns, which ſometimes happens, have become no longer viſible.

But conjectures of this kind, which no reaſoning can aſcertain, nor experiment reach, are rather amuſing than uſeful. Though we ſee the greatneſs and wiſdom of the Deity in all the ſeeming worlds that ſurround us, it is our chief concern to trace him in that which

we inhabit. The examination of the earth, the wonders of its contrivance, the hiſtory of its advantages, or of the ſeeming defects in its formation, are the proper buſineſs of the *natural hiſtorian*. A deſcription of this earth, its *animals*, *vegetables*, and *minerals*, is the moſt delightful entertainment the mind can be furniſhed with, as it is the moſt intereſting and uſeful. I would beg leave, therefore, to conclude theſe common-place ſpeculations, with an obſervation, which, I hope, is not entirely ſo.

An uſe, hitherto not much inſiſted upon, that may reſult from the contemplation of celeſtial magnificence, is, that it will teach us to make an allowance for the apparent irregularities we find below. Whenever we can examine the works of the Deity at a proper point of diſtance, ſo as to take in the whole of his deſign, we ſee nothing but uniformity, beauty, and preciſion. The heavens preſent us with a plan, which, though inexpreſſibly magnificent, is yet regular beyond the power of invention. Whenever, therefore, we find any apparent defects in the earth, which we are about to conſider, inſtead of attempting to reaſon ourſelves into an opinion that they are beautiful, it will be wiſe to ſay, that we do not behold them at the proper

point of diſtance, and that our eye is laid too cloſe to the objects to take in the regularity of their connexion. In ſhort, we may conclude, that God, who is regular in his great productions, acts with equal uniformity in the little.

CHAP. II.

A ſhort Survey of the Globe, from the light of Aſtronomy and Geography.

ALL the ſciences are in ſome meaſure linked with each other, and before the one is ended the other begins. In a natural hiſtory, therefore of the earth, we muſt begin with a ſhort account of its ſituation and form, as given us by aſtronomers and geographers: it will be ſufficient however, upon this occaſion, juſt to hint to the imagination, what they, by the moſt abſtract reaſonings, have forced upon the underſtanding. The earth we inhabit is, as has been ſaid before, one of thoſe bodies which circulate in our ſolar ſyſtem; it is placed at an happy middle diſtance from the centre; and even ſeems, in this reſpect, privileged beyond all other planets that depend upon our great luminary for their ſupport. Leſs diſtant from the ſun than Saturn, Jupiter,

and Mars, and yet leſs parched up than Venus and Mercury, that are ſituate too near the violence of its power, the earth ſeems in a peculiar manner to ſhare the bounty of the Creator: it is not, therefore, without reaſon, that mankind conſider themſelves as the peculiar objects of his providence and regard.

Beſides that motion which the earth has round the ſun, the circuit of which is performed in a year, it has another upon its own axle, which it performs in twenty-four hours. Thus, like a chariot-wheel, it has a compound motion; for while it goes forward on its journey, it is at the ſame time turning upon itſelf. From the firſt of theſe two ariſe the grateful viciſſitude of the ſeaſons; from the ſecond, that of day and night.

It may be alſo readily conceived, that a body thus wheeling in circles will moſt probably be itſelf a ſphere. The earth, beyond all poſſibility of doubt, is found to be ſo. Whenever its ſhadow happens to fall upon the moon, in an eclipſe, it appears to be always circular, in whatever poſition it is projected: and it is eaſy to prove, that a body which in every poſition makes a circular ſhadow, muſt itſelf be round. The rotundity of the earth may be alſo proved from the meeting of two ſhips at ſea: the top

mafts of each are the firft parts that are difcovered by both, the under parts being hidden by the convexity of the globe which rifes between them. The fhips in this inftance may be refembled to two men who approach each other on the oppofite fides of an hill: their heads will firft be feen, and gradually as they come nearer they will come entirely into view.

However, though the earth's figure is faid to be fpherical, we ought only to conceive it as being nearly fo. It has been found in the laft age to be rather flatted at both poles, fo that its form is commonly refembled to that of a turnep. The caufe of this fwelling of the equator is afcribed to the greater rapidity of the motion with which the parts of the earth are there carried round; and which, confequently, endeavouring to fly off, act in oppofition to central attraction. The twirling of a mop may ferve as an homely illuftration; which, as every one has feen, fpreads and grows broader in the middle as it continues to be turned round.

As the earth receives light and motion from the fun, fo it derives much of its warmth and power of vegetation from the fame beneficent fource. However, the different parts of the globe participate of thefe advantages in very

different proportions, and accordingly put on very different appearances; a polar profpect, and a landfcape at the equator, are as oppofite in their appearances as in their fituation.

The polar regions, that receive the folar beams in a very oblique direction, and continue for one half of the year in night, receive but few of the genial comforts which other parts of the world enjoy. Nothing can be more mournful or hideous than the picture which travellers prefent of thofe wretched regions. The ground *, which is rocky and barren, rears itfelf in every place in lofty mountains and inacceffible cliffs, and meets the mariner's eye at forty leagues from fhore. Thefe precipices, frightful in themfelves, receive an additional horror from being conftantly covered with ice and fnow, which daily feem to accumulate and to fill all the vallies with encreafing defolation. The few rocks and cliffs, that are bare of fnow, look at a diftance of a dark brown colour, and quite naked. Upon a nearer approach, however, they are found replete with many different veins of coloured ftone, here and there fpread over with a little earth, and a fcanty portion of grafs and heath. The internal parts of the country are

* Krantz's hiftory of Greenland, p. 3.

ſtill more deſolate and deterring. In wandering through theſe ſolitudes, ſome plains appear covered with ice, that, at firſt glance, ſeem to promiſe the traveller an eaſy journey *. But theſe are even more formidable and more unpaſſable than the mountains themſelves, being cleft with dreadful chaſms, and every where abounding with pits that threaten certain deſtruction. The ſeas that ſurround theſe inhoſpitable coaſts, are ſtill more aſtoniſhing, being covered with flakes of floating ice, that ſpread like extenſive fields, or that riſe out of the water like enormous mountains. Theſe, which are compoſed of materials as clear and tranſparent as glaſs †, aſſume many ſtrange and fantaſtic appearances. Some of them look like churches or caſtles, with pointed turrets; ſome like ſhips in full ſail; and people have often given themſelves the fruitleſs toil to attempt piloting the imaginary veſſels into harbour. There are ſtill others that appear like large iſlands, with plains, valleys, and hills, which often rear their heads two hundred yards above the level of the ſea; and although the height of theſe be amazing, yet their depth beneath is ſtill more ſo; ſome of them being found to ſink three hundred fathom under water.

* Krantz's Hiſtory of Greenland, p. 22. † Ibid. 27.

The earth presents a very different appearance at the equator, where the sun-beams, darting directly downwards, burn up the lighter soils into extensive sandy deserts, or quicken all the moister tracts with incredible vegetation. In these regions, almost all the same inconveniencies are felt from the proximity of the sun, that in the former were endured from its absence. The deserts are entirely barren; except where they are found to produce serpents, and in such quantities, that some extensive plains seem almost entirely covered with them *.

It not unfrequently happens also that this dry soil, which is so parched and comminuted by the force of the sun, rises with the smallest breeze of wind; and the sands being composed of parts almost as small as those of water, they assume a similar appearance, rolling onward in waves like those of a troubled sea, and overwhelming all they meet with inevitable destruction. On the other hand, those tracts which are fertile, teem with vegetation even to a noxious degree. The grass rises to such an height as often to require burning; the forests are impassable from underwoods, and so matted above, that even the sun, fierce as it is, can seldom penetrate †. These are so thick as

* Adanson's Description of Senegal.

† Linnæ Amænit. vol. vi. p. 67.

ſcarce to be extirpated; for the tops being ſo bound together by the climbing plants that grow round them, though an hundred ſhould be cut at the bottom, yet not one would fall, as they mutually ſupport each other. In theſe dark and tangled foreſts, beaſts of various kinds, inſects in aſtoniſhing abundance, and ſerpents of ſurpriſing magnitude, find a quiet retreat from man, and are ſeldom diſturbed except by each other.

In this manner the extremes of our globe ſeem equally unfitted for the comforts and conveniencies of life; and, although the imagination may find an awful pleaſure in contemplating the frightful precipices of Greenland, or the luxurious verdure of Africa, yet true happineſs can only be found in the more moderate climates, where the gifts of nature may be enjoyed without incurring danger in obtaining them.

It is in the temperate zone, therefore, that all the arts of improving nature, and refining upon happineſs, have been invented: and this part of the earth is, more properly ſpeaking, the theatre of natural hiſtory. Although there be millions of animals and vegetables in the unexplored foreſts under the line, yet moſt of theſe may for ever continue unknown, as

curiofity is there repreffed by furrounding danger. But it is otherwife in thefe delightful regions which we inhabit, and where this art has had its beginning. Among us there is fcarce a fhrub, a flower, or an infect, without its particular hiftory; fcarce a plant that could be ufeful which has not been propagated; nor a weed that could be noxious which has not been pointed out.

CHAP. III.

A View of the Surface of the Earth.

WHEN we take a flight furvey of the furface of our globe, a thoufand objects offer themfelves, which, though long known, yet ftill demand our curiofity. The moft obvious beauty that every where ftrikes the eye is the verdant covering of the earth, which is formed by an happy mixture of herbs and trees of various magnitudes and ufes. If has been often remarked that no colour refrefhes the fight fo much as green; and it may be added, as a further proof of the affertion, that the inhabitants of thofe places where the fields are continually white with fnow, generally become blind long before the ufual courfe of nature.

This advantage, which arifes from the verdure of the fields, is not a little improved by their agreeable inequalities. There is fcarce two natural landfcapes that offer profpects entirely refembling each other; their rifings and depreffions, their hills and valleys, are never entirely the fame, but always offer fomething new to entertain and refrefh the imagination.

But to encreafe the beauties of the face of nature, the landfcape is enlivened by fprings and lakes, and interfected by rivulets. Thefe lend a brightnefs to the profpect; give motion and coolnefs to the air; and, what is much more important, furnifh health and fubfiftence to animated nature.

Such are the moft obvious and tranquil objects that every where offer: but there are objects of a more awful and magnificent kind; the *Mountain* rifing above the clouds, and topt with fnow; the *River* pouring down its fides, encreafing as it runs, and lofing itfelf, at laft, in the ocean; the *Ocean* fpreading its immenfe fheet of waters over one half of the globe, fwelling and fubfiding at well-known intervals, and forming a communication between the moft diftant parts of the earth.

If we leave thofe objects that feem to be natural to our earth, and keep the fame con-

ſtant tenor, we are preſented with the great irregularities of nature. The burning mountain; the abrupt precipice; the unfathomable cavern; the headlong cataract; and the rapid whirlpool.

If we carry our curioſity a little further, and deſcend to the objects immediately below the ſurface of the globe, we ſhall there find wonders ſtill as amazing. We firſt perceive the earth for the moſt part lying in regular beds or layers, every bed growing thicker in proportion as it lies deeper, and its contents more compact and heavy. We ſhall find, almoſt wherever we make our ſubterranean enquiry, an amazing number of ſhells that belonged to aquatic animals. Here and there, at a diſtance from the ſea, beds of oyſter-ſhells, ſeveral yards thick, and many miles over; ſometimes teſtaceous ſubſtances of various kinds on the tops of mountains, and often in the heart of the hardeſt marble. Theſe, which are dug up by the peaſants, in every country, are regarded with little curioſity; for being ſo very common, they are conſidered as ſubſtances entirely terrene. But it is otherwiſe with the enquirer after nature, who finds them, not only in ſhape but in ſubſtance, every way reſembling thoſe that are found in the ſea; and he,

therefore, is at a loſs to account for their removal.

Yet not one part of nature alone, but all her productions and varieties, become the object of the ſpeculative man's enquiry: he takes different views of nature from the inattentive ſpectator; and ſcarce an appearance, how common ſoever, but affords matter for his contemplation: he enquires how and why the ſurface of the earth has thoſe riſings and depreſſions which moſt men call natural; he demands in what manner the mountains were formed, and in what conſiſt their uſes; he aſks from whence ſprings ariſe, and how rivers flow round the convexity of the globe; he enters into an examination of the ebbings and flowings, and the other wonders of the deep; he acquaints himſelf with the irregularities of nature, and endeavours to inveſtigate their cauſes; by which, at leaſt, he will become better verſed in their hiſtory. The internal ſtructure of the globe becomes an object of his curioſity; and, although his enquiries can fathom but a very little way, yet, if poſſeſſed with a ſpirit of theory, his imagination will ſupply the reſt. He will endeavour to account for the ſituation of the marine foſſils that are found in the earth, and for the ap-

pearance of the different beds of which it is composed. These have been the enquiries that have splendidly employed many of the philosophers of the last and present age * ; and, to a certain degree, they must be serviceable. But the worst of it is, that, as speculations amuse the writer more than facts, they may be often carried to an extravagant length; and that time may be spent in reasoning upon nature, which might be more usefully employed in writing her history.

Too much speculation in natural history is certainly wrong; but there is a defect of an opposite nature that does much more prejudice; namely, that of silencing all enquiry, by alledging the benefits we receive from a thing, instead of investigating the cause of its production. If I enquire how a mountain came to be formed, such a reasoner, enumerating its benefits, answers, because God knew it would be useful. If I demand the cause of an earthquake, he finds some good produced by it, and alledges that as the cause of its explosion. Thus such an enquirer has constantly some ready reason for every appearance in nature, which serves to swell his periods, and give splendour

* Buffon, Woodward, Burnet, Whiston, Kircher, Bourquet, Leibnitz, Steno, Ray, &c.

to his declamation: every thing about him is, on ſome account or other, declared to be good; and he thinks it preſumption to ſcrutinize its defects, or endeavour to imagine how it might be better. Such writers, and there are many ſuch, add very little to the advancement of knowledge. It is finely remarked by Bacon, that the inveſtigation of final cauſes * is a barren ſtudy; and, like a virgin dedicated to the Deity, brings forth nothing. In fact, thoſe men who want to compel every appearance and every irregularity in nature into our ſervice, and expatiate on their benefits, combat that very morality which they would ſeem to promote. God has permitted thouſands of natural evils to exiſt in the world, becauſe it is by their intervention that man is capable of moral evil; and he has permitted that we ſhould be ſubject to moral evil, that we might do ſomething to deſerve eternal happineſs by ſhewing we had rectitude to avoid it.

* Inveſtigatio cauſarum finalium ſterilis eſt, et veluti virgo Deo dedicata, nil parit.

[library stamp]

CHAP. IV.

A Review of the different Theories of the Earth.

HUMAN invention has been exercifed for feveral ages to account for the various irregularities of the earth. While thofe philofophers mentioned in the laft chapter fee nothing but beauty, fymmetry, and order; there are others, who look upon the gloomy fide of nature, enlarge on its defects, and feem to confider the earth, on which they tread, as one fcene of extenfive defolation *. Beneath its furface they obferve minerals and waters confufedly jumbled together; its different beds of earth irregularly lying upon each other; mountains rifing from places that once were level †; and hills finking into vallies; whole regions fwallowed by the fea, and others again rifing out of its bofom: all thefe they fuppofe to be but a few of the changes that have been wrought in our globe; and they fend out the imagination to defcribe its primæval ftate of beauty.

Of thofe who have written theories defcribing the manner of the original formation of the

* Buffon's fecond difcourfe.
† Senec. Quæft. lib. vi. cap. 21.

earth, or accounting for its preſent appearances, the moſt celebrated are Burnet, Whiſton, Woodward, and Buffon. As ſpeculation is endleſs, ſo it is not to be wondered that all theſe differ from each other, and give oppoſite accounts of the ſeveral changes, which they ſuppoſe our earth to have undergone. As the ſyſtems of each have had their admirers, it is, in ſome meaſure, incumbent upon the natural hiſtorian to be acquainted, at leaſt, with their out-lines; and, indeed, to know what others have even dreamed, in matters of ſcience, is very uſeful, as it may often prevent us from indulging ſimilar deluſions ourſelves, which we ſhould never have adopted, but becauſe we take them to be wholly our own. However, as entering into a detail of theſe theories, is rather furniſhing an hiſtory of opinions than things, I will endeavour to be as conciſe as I can.

The firſt who formed this amuſement of earth-making into ſyſtem was the celebrated Thomas Burnet, a man of polite learning and rapid imagination. His *Sacred Theory*, as he calls it, deſcribing the changes which the earth has undergone, or ſhall hereafter undergo, is well known for the warmth with which it is imagined, and the weakneſs with which it

is reaſoned, for the elegance of its ſtyle, and the meanneſs of its philoſophy. The earth, ſays he, before the deluge, was very differently formed for what it it at preſent: it was at firſt a fluid maſs; a chaos compoſed of various ſubſtances, differing both in denſity and figure: thoſe which were moſt heavy ſunk to the centre, and formed in the middle of our globe an hard ſolid body; thoſe of a lighter nature remained next; and the waters, which were lighter ſtill, ſwam upon its ſurface, and covered the earth on every ſide. The air, and all thoſe fluids which were lighter than water, floated upon this alſo; and in the ſame manner encompaſſed the globe; ſo that between the ſurrounding body of waters, and the circumambient air, there was formed a coat of oil, and other unctuous ſubſtances, lighter than water. However, as the air was ſtill extremely impure, and muſt have carried up with it many of thoſe earthy particles with which it once was intimately blended, it ſoon began to defecate, and to depoſe theſe particles upon the oily ſurface already mentioned, which ſoon uniting, the earth and oil formed that cruſt, which ſoon became an habitable ſurface, giving life to vegetation, and dwelling to animals.

This imaginary antideluvian abode was

very different from what we ſee it at preſent. The earth was light and rich; and formed of a ſubſtance entirely adapted to the feeble ſtate of incipient vegetation: it was an uniform plain, every where covered with verdure; without mountains, without ſeas, or the ſmalleſt inequalities. It had no difference of ſeaſons, for its equator was in the plain of the ecliptic, or, in other words, it turned directly oppoſite to the ſun, ſo that it enjoyed one perpetual and luxuriant ſpring. However, this delightful face of nature did not long continue in the ſame ſtate; for, after a time, it began to crack and open in fiſſures: a circumſtance which always ſucceeds when the ſun exhales the moiſture from rich or marſhy ſituations. The crimes of mankind had been for ſome time preparing to draw down the wrath of Heaven; and they, at length, induced the Deity to defer repairing theſe breaches in nature. Thus the chaſms of the earth every day became wider, and, at length, they penetrated to the great abyſs of waters; and the whole earth, in a manner, fell in. Then enſued a total diſorder in the uniform beauty of the firſt creation, the terrene ſurface of the globe being broken down: as it ſunk the waters guſhed out in its place; the deluge became univerſal; all mankind, except eight perſons,

were destroyed, and their posterity condemned to toil upon the ruins of desolated nature.

It only remains to mention the manner in which he relieves the earth from this universal wreck, which would seem to be as difficult as even its first formation. "These great masses of earth falling into the abyss, drew down with them vast quantities also of air; and by dashing against each other, and breaking into small parts by the repeated violence of the shock, they, at length, left between them large cavities filled with nothing but air. These cavities naturally offered a bed to receive the influent waters; and in proportion as they filled, the face of the earth became once more visible. The higher parts of its broken surface, now become the tops of mountains, were the first that appeared; the plains soon after came forward, and, at length, the whole globe was delivered from the waters, except the places in the lowest situations; so that the ocean and the seas are still a part of the ancient abyss that have not had a place to return. Islands and rocks are fragments of the earth's former crust; kingdoms and continents are larger masses of its broken substance; and all the inequalities that are to be found on the surface of the present earth, are owing to the acci-

dental confuſion into which both earth and waters were then thrown."

The next theoriſt was Woodward, who, in his Eſſay towards a Natural Hiſtory of the Earth, which was only deſigned to precede a greater work, has endeavoured to give a more rational account of its appearances; and was, in fact, much better furniſhed for ſuch an undertaking than any of his predeceſſors, being one of the moſt aſſiduous naturaliſts of his time. His little book, therefore, contains many important facts, relative to natural hiſtory, although his ſyſtem may be weak and groundleſs.

He begins by aſſerting that all terrene ſubſtances are diſpoſed in beds of various natures, lying horizontally one over the other, ſomewhat like the coats of an onion; that they are replete with ſhells, and other productions of the ſea: theſe ſhells being found in the deepeſt cavities, and on the tops of the higheſt mountains. From theſe obſervations, which are warranted by experience, he proceeds to obſerve, that theſe ſhells and extraneous foſſils are not productions of the earth, but are all actual remains of thoſe animals which they are known to reſemble; that all the beds of the earth lie under each other, in the order of their ſpecific gravity; and that they are diſpoſed as if they had been left there by ſubſiding waters. All theſe

aſſertions he affirms with much earneſtneſs, although daily experience contradicts him in ſome of them; particularly we find layers of ſtone often over the lighteſt ſoils, and the ſofteſt earth under the hardeſt bodies. However, having taken it for granted, that all the layers of the earth are found in the order of their ſpecific gravity, the lighteſt at the top, and the heavieſt next the centre, he conſequently aſſerts, and it will not improbably follow, that all the ſubſtances of which the earth is compoſed, were once in an actual ſtate of diſſolution. This univerſal diſſolution he takes to have happened at the time of the flood. He ſuppoſes that at that time a body of water, which was then in the centre of the earth, uniting with that which was found on the ſurface, ſo far ſeparated the terrene parts as to mix all together in one fluid maſs; the contents of which afterwards ſinking according to their reſpective gravities, produced the preſent appearances of the earth. Being aware, however, of an objection that foſſile ſubſtances are not found diſſolved, he exempts them from this univerſal diſſolution, and, for that purpoſe, endeavours to ſhew that the parts of animals have a ſtronger coheſion than thoſe of minerals; and that, while even the hardeſt rocks may be diſſolved, bones and ſhells may ſtill continue entire.

So much for Woodward; but of all the syſtems which were publiſhed reſpecting the earth's formation, that of Whiſton was moſt applauded, and moſt oppoſed. Nor need we wonder; for being ſupported with all the parade of deep calculation, it awed the ignorant, and produced the approbation of ſuch as would be thought otherwiſe, as it implied a knowledge of abſtruſe learning, to be even thought capable of comprehending what the writer aimed at. In fact, it is not eaſy to diveſt this theory of its mathematical garb; but thoſe who have had leiſure, have found the reſult of our philoſopher's reaſoning to be thus. He ſuppoſes the earth to have been originally a comet; and he conſiders the hiſtory of the creation, as given us in ſcripture, to have its commencement juſt when it was, by the hand of the Creator, more regularly placed as a planet in our ſolar ſyſtem. Before that time, he ſuppoſes it to have been a globe without beauty or proportion; a world in diſorder; ſubject to all the viciſſitudes which comets endure; ſome of which have been found, at different times, a thouſand times hotter than melted iron; at others, a thouſand times colder than ice. Theſe alternations of heat and cold, continually melting and freezing the ſurface of the earth, he ſuppoſes to have produced, to a certain

depth, a chaos entirely refembling that defcribed by the poets, furrounding the folid contents of the earth, which ftill continued unchanged in the midft, making a great burning globe of more than two thoufand leagues in diameter. This furrounding chaos, however, was far from being folid: he refembles it to a denfe though fluid atmofphere, compofed of fubftances mingled, agitated, and fhocked againft each other; and in this diforder he defcribes the earth to have been juft at the eve of creation.

But upon its orbit's being then changed, when it was more regularly wheeled round the fun, every thing took its proper place; every part of the furrounding fluid then fell into a fituation, in proportion as it was light or heavy. The middle, or central part, which always remained unchanged, ftill continued fo, retaining a part of that heat which it received in its primæval approaches towards the fun; which heat, he calculates, may continue for about fix thoufand years. Next to this fell the heavier parts of the chaotic atmofphere, which ferve to fuftain the lighter: but as in defcending they could not entirely be feparated from many watery parts, with which they were intimately mixed, they drew down a part of thefe alfo with them; and thefe could not mount again after the

surface of the earth was consolidated: they, therefore, surrounded the heavy first descending parts, in the same manner as these surround the central globe. Thus the entire body of the earth is composed internally of a great burning globe: next which, is placed an heavy terrene substance, that encompasses it; round which also is circumfused a body of water. Upon this body of water, the crust of earth on which we inhabit is placed: so that, according to him, the globe is composed of a number of coats, or shells, one within the other, all of different densities. The body of the earth being thus formed, the air, which is the lightest substance of all, surrounded its surface; and the beams of the sun darting through, produced that light which, we are told, first obeyed the Creator's command.

The whole œconomy of the creation being thus adjusted, it only remained to account for the risings and depressions on the surface of the earth, with the other seeming irregularities of its present appearance. The hills and vallies are considered by him as formed by their pressing upon the internal fluid, which sustains the outward shell of earth, with greater or less weight: those parts of the earth which are heaviest, sink into the subjacent fluid more

deeply, and become vallies: thofe that are lighteft rife higher upon the earth's furface, and are called mountains.

Such was the face of nature before the deluge; the earth was then more fertile and populous than it is at prefent; the life of man and animals was extended to ten times its prefent duration; and all thefe advantages arofe from the fuperior heat of the central globe, which ever fince has been cooling. As its heat was then in full power, the genial principle was alfo much greater than at prefent; vegetation and animal increafe were carried on with more vigour; and all nature feemed teeming with the feeds of life. But thefe phyfical advantages were only productive of moral evil; the warmth which invigorated the body encreafed the paffions and appetites of the mind; and, as man became more powerful, he grew lefs innocent. It was found neceffary to punifh this depravity; and all living creatures were overwhelmed by the deluge in univerfal deftruction.

This deluge, which fimple believers are willing to afcribe to a miracle, philofophers have long been defirous to account for by natural caufes: they have proved that the earth

could never ſupply from any reſervoir towards its centre, nor the atmoſphere by any diſcharge from above, ſuch a quantity of water as would cover the ſurface of the globe to a certain depth over the tops of our higheſt mountains. Where, therefore, was all this water to be found? Whiſton has found enough, and more than a ſufficiency, in the tail of a comet; for he ſeems to allot comets a very active part in the great operations of nature.

He calculates, with great ſeeming preciſion, the year, the month, and the day of the week on which this comet (which has paid the earth ſome viſits ſince, though at a kinder diſtance) involved our globe in its tail. The tail he ſuppoſed to be a vaporous fluid ſubſtance, exhaled from the body of the comet, by the extreme heat of the ſun, and encreaſing in proportion as it approached that great luminary. It was in this that our globe was involved at the time of the deluge; and, as the earth ſtill acted by its natural attraction, it drew to itſelf all the watery vapours which were in the comet's tail; and the internal waters being alſo at the ſame time let looſe, in a very ſhort ſpace the tops of the higheſt mountains were laid under the deep.

The punishment of the deluge being thus completed, and all the guilty destroyed, the earth, which had been broken by the eruption of the internal waters, was also enlarged by it; so that upon the comet's recess, there was found room sufficient in the internal abyss for the recess of the superfluous waters; whither they all retired, and left the earth uncovered, but in some respects changed, particularly in its figure, which, from being round, was now become oblate. In this universal wreck of nature Noah survived, by a variety of happy causes, to re-people the earth, and to give birth to a race of men slow in believing ill-imagined theories of the earth.

After so many theories of the earth, which had been published, applauded, answered, and forgotten, Mr. Buffon ventured to add one more to the number. This philosopher was, in every respect, better qualified than any of his predecessors for such an attempt, being furnished with more materials, having a brighter imagination to find new proofs, and a better style to cloath them in. However, if one so ill qualified, as I am, may judge, this seems the weakest part of his admirable work; and I could wish, that he had been content with giving us facts instead of systems; that, in-

ſtead of being a reaſoner, he had contented himſelf with being merely an hiſtorian.

He begins his ſyſtem by making a diſtinction between the firſt part of it and the laſt; the one being founded only on conjecture, the other depending entirely upon actual obſervation. The latter part of his theory may, therefore, be true, though the former ſhould be found erroneous.

The planets, ſays he, and the earth, among the number, might have been formerly (he only offers this as conjecture) a part of the body of the ſun, and adherent to its ſubſtance. In this ſituation, a comet falling in upon that great body might have given it ſuch a ſhock, and ſo ſhaken its whole frame, that ſome of its particles might have been driven off like ſtreaming ſparkles from red hot iron; and each of theſe ſtreams of fire, ſmall as they were in compariſon of the ſun, might have been large enough to have made an earth as great, nay many times greater than ours. So that in this manner the planets, together with the globe which we inhabit, might have been driven off from the body of the ſun by an impulſive force: in this manner alſo they would continue to recede from it for ever, were they not drawn back by its ſuperior power of attraction; and

thus, by the combination of the two motions, they are wheeled round in circles.

Being in this manner detached at a diſtance from the body of the ſun, the planets, from having been at firſt globes of liquid fire, gradually became cool. The earth alſo having been impelled obliquely forward, received a rotatory motion upon its axis at the very inſtant of its formation; and this motion being greateſt at the equator, the parts there acting againſt the force of gravity, they muſt have ſwollen out, and given the earth an oblate or flatted figure.

As to its internal ſubſtance, our globe having once belonged to the ſun, it continues to be an uniform maſs of melted matter, very probably vitrified in its primæval fuſion. But its ſurface is very differently compoſed. Having been in the beginning heated to a degree equal to, if not greater, than what comets are found to ſuſtain, like them it had an atmoſphere of vapours floating round it, and which cooling by degrees, condenſed and ſubſided upon its ſurface. Theſe vapours formed, according to their different denſities, the earth, the water, and the air; the heavier parts falling firſt, and the lighter remaining ſtill ſuſpended.

Thus far our philosopher is, at least, as much a system-maker as Whiston or Burnet; and, indeed, he fights his way with great perseverance and ingenuity through a thousand objections that naturally arise. Having, at last, got upon the earth, he supposes himself on firmer ground, and goes forward with greater security. Turning his attention to the present appearance of things upon this globe, he pronounces from the view that the whole earth was at first under water. This water he supposes to have been the lighter parts of its former evaporation, which, while the earthy particles sunk downwards by their natural gravity, floated on the surface, and covered it for a considerable space of time.

"The surface of the earth," says he*, "must have been in the beginning much less solid than it is at present; and, consequently, the same causes, which at this day produce but very slight changes, must then, upon so complying a substance, have had very considerable effects. We have no reason to doubt but that it was then covered with the waters of the sea; and that those waters were above the tops of our highest mountains, since, even in such

* Theorie de la Terre, vol. i. p. 121.

elevated ſituations, we find ſhells and other marine productions in very great abundance. It appears alſo that the ſea continued for a conſiderable time upon the face of the earth: for as theſe layers of ſhells are found ſo very frequent at ſuch great depths, and in ſuch prodigious quantities, it ſeems impoſſible for ſuch numbers to have been ſupported all alive at one time; ſo that they muſt have been brought there by ſucceſſive depoſitions. Theſe ſhells alſo are found in the bodies of the hardeſt rocks, where they could not have been depoſited, all at once, at the time of the deluge, or at any ſuch inſtant revolution; ſince that would be to ſuppoſe, that all the rocks in which they are found, were, at that inſtant, in a ſtate of diſſolution, which would be abſurd to aſſert. The ſea, therefore, depoſited them whereſoever they are now to be found, and that by ſlow and ſucceſſive degrees.

It will appear, alſo, that the ſea covered the whole earth, from the appearance of its layers, which lying regularly one above the other, ſeem all to reſemble the ſediment formed at different times by the ocean. Hence, by the irregular force of its waves, and its currents driving the bottom into ſand-banks, mountains muſt have been gradually formed within this univerſal

covering of waters; and thefe fucceffively raif-ing their heads above its furface, muft, in time, have formed the higheft ridges of mountains upon land, together with continents, iflands and low grounds, all in their turns. This opi-nion will receive additional weight by confi-dering, that in thofe parts of the earth where the power of the ocean is greateft, the inequa-lities on the furface of the earth are higheft: the ocean's power is greateft at the equator, where its winds and tides are moft conftant; and, in fact, the mountains at the equator are found to be higher than in any other part of the world. The fea, therefore, has produced the principal changes in our earth: rivers, volcanoes, earthquakes, ftorms, and rain, hav-ing made but flight alterations, and only fuch as have affected the globe to very inconfider-able depths."

This is but a very flight fketch of Mr. Buf-fon's Theory of the Earth; a theory which he has much more powerfully fupported, than happily invented; and it would be needlefs to take up the reader's time from the purfuit of truth in the difcuffion of plaufibilities. In fact, a thoufand queftions might be afked this moft ingenious philofopher, which he would not find it eafy to anfwer; but fuch is the lot of

humanity, that a ſingle Goth can in one day deſtroy the fabric which Cæſars were employed an age in erecting. We might aſk, how mountains, which are compoſed of the moſt compact and ponderous ſubſtances, ſhould be the firſt whoſe parts the ſea began to remove? We might aſk, how foſſil-wood is found deeper even than ſhells? which argues, that trees grew upon the places he ſuppoſes once to have been covered with the ocean. But we hope this excellent man is better employed than to think of gratifying the petulance of incredulity, by anſwering endleſs objections.

CHAP. V.

Of Foſſil-ſhells, and other extraneous Foſſils.

WE may affirm of Mr. Buffon, that which has been ſaid of the chymiſts of old: though he may have failed in attaining his principal aim, of eſtabliſhing a theory, yet he has brought together ſuch a multitude of facts relative to the hiſtory of the earth, and the nature of its

fame effects in medicine when inwardly administered; and, in a word, were so exactly conformable to marine bodies, that they had all the accidental concretions growing to them, (such as pearls, corals, and smaller shells) which are found in shells just gathered on the shore. They were, therefore, from these considerations, given back to the sea; but the wonder was, how to account for their coming so far from their own natural element upon land*.

As this naturally gave rise to many conjectures, it is not to be wondered that some among them have been very extraordinary. An Italian, quoted by Mr. Buffon, supposes them to have been deposited in the earth at the time of the crusades, by the pilgrims who returned from Jerusalem: who gathering them upon the sea-shore, in their return carried them to their different places of habitation. But this conjecturer seems to have but a very inadequate idea of their numbers. At Touraine, in France, more than an hundred miles from the sea, there is a plain of about nine leagues long, and as many broad, from whence the peasants of the country supply themselves with marle for

* Woodward, p. 43.

manuring their lands. They ſeldom dig deeper than twenty feet, and the whole plain is compoſed of the ſame materials, which are ſhells of various kinds, without the ſmalleſt portion of earth between them. Here then, is a large ſpace, in which are depoſited millions of tons of ſhells, that pilgrims could not have collected, though their whole employment had been nothing elſe. England is furniſhed with its beds, which though not quite ſo extenſive, yet are equally wonderful. * "Near Reading, in Berkſhire, for many ſucceeding generations, a continued body of oyſter-ſhells has been found through the whole circumference of five or ſix acres of ground. The foundation of theſe ſhells is an hard rocky chalk; and above this chalk, the oyſter-ſhells lie in a bed of green ſand, upon a level, as nigh as can poſſibly be judged, and about two feet thickneſs." Theſe ſhells are in their natural ſtate, but they were found alſo petrified, and almoſt in equal abundance † in all the Alpine rocks, in the Pyrenees, on the hills of France, England, and Flanders. Even in all quar-

* Phil. Tranſ. vol. ii. p. 427.

† Buffon, vol. i. p. 407.

ries from whence marble is dug, if the rocks be ſplit perpendicularly downwards, petrified ſhells, and other marine ſubſtances, will be plainly diſcerned.

"About a quarter of a mile from the river Medway *, in the county of Kent, after the taking off the coping of a piece of ground there, the workmen came to a blue marble, which continued for three feet and an half deep, or more, and then beneath appeared an hard floor, or pavement, compoſed of petrified ſhells crowded cloſely together. This layer was about an inch deep, and ſeveral yards over; and it could be walked upon as upon a beach. Theſe ſtones, of which it was compoſed, (the deſcriber ſuppoſes them to have always been ſtones) were either wreathed as ſnails, or bivalvular like cockles. The wreathed kinds were about the ſize of an hazle-nut, and were filled with a ſtony ſubſtance of the colour of marle; and they themſelves, alſo, till they were waſhed, were of the ſame colour; but when cleaned, they appeared of the colour of bezoar, and of the ſame poliſh. After boiling in water they became whitiſh, and left a chalkineſs upon the fingers."

* Phil. Tranſ. p. 426.

In ſeveral parts of Aſia and Africa, travellers have obſerved theſe ſhells in great abundance. In the mountains of Caſtravan, which lie above the city Barut, they quarry out a white ſtone, every part of which contains petrified fiſhes in great numbers, and of ſurpriſing diverſity. They alſo ſeem to continue in ſuch preſervation, that their fins, ſcales, and all the minuteſt diſtinctions of their make, can be perfectly diſcerned *.

From all theſe inſtances we may conclude, that foſſils are very numerous; and, indeed, independent of their ſituation, they afford no ſmall entertainment to obſerve them as preſerved in the cabinets of the curious. The varieties of their kinds is aſtoniſhing. Moſt of the ſea ſhells which are known, and many others to which we are entirely ſtrangers, are to be ſeen either in their natural ſtate, or in various degrees of petrefaction †. In the place of ſome we have mere ſpar, or ſtone, exactly expreſſing all the lineaments of animals, as having been wholly formed from them. For it has happened, that the ſhells diſſolving by very ſlow degrees, and the matter having nicely and exactly filled all the cavities within, this matter,

* Buffon, vol. i. p. 408. † Hill, p. 646.

after the ſhells have periſhed, has preſerved exactly and regularly the whole print of their internal ſurface. Of theſe there are various kinds found in our pits; many of them reſembling thoſe of our own ſhores; and many others that are only to be found on the coaſts of other countries. There are ſome ſhells reſembling thoſe that are never ſtranded upon our coaſts *, but always remain in the deep †: and many more there are which we can aſſimilate with no ſhells known amongſt us. But we find not only ſhells in our pits, but alſo fiſhes and corals in great abundance; together with almoſt every ſort of marine production.

It is extraordinary enough, however, that the common red coral, though ſo very frequent at ſea, is ſcarce ſeen in the foſſil world; nor is there any account of its having ever been met with. But to compenſate for this, there are all the kinds of the white coral now known; and many other kinds of that ſubſtance with which we are unacquainted. Of animals there are various parts; the vertebræ of whales, and the mouths of leſſer fiſhes; theſe,

* Littorales. † Pelagii.

with teeth alſo of various kinds, are found in the cabinets of the curious; where they receive long Greek names, which it is neither the intention nor the province of this work to enumerate. Indeed, few readers would think themſelves much improved, ſhould I proceed with enumerating the various claſſes of the Conicthyodontes, Polyleptoginglimi, or the Orthoceratites. Theſe names, which mean no great matter when they are explained, may ſerve to guide in the furniſhing a cabinet; but they are of very little ſervice in furniſhing the page of inſtructive hiſtory.

From all theſe inſtances we ſee in what abundance petrefactions are to be found; and, indeed, Mr. Buffon, to whoſe accounts we have added ſome, has not been ſparing in the variety of his quotations, concerning the places where they are moſtly to be found. However, I am ſurpriſed that he ſhould have omitted the mention of one, which, in ſome meaſure, more than any of the reſt, would have ſerved to ſtrengthen his theory. We are informed, by almoſt every traveller *, that has deſcribed the pyramids of Egypt, that one of them is entirely built of a kind of free-ſtone,

* Haſſelquiſt, Sandys.

in which these petrified shells are found in great abundance. This being the case, it may be conjectured, as we have accounts of these pyramids among the earliest records of mankind, and of their being built so long before the age of Herodotus, who lived but fifteen hundred years after the flood, that even the Egyptian priests could tell neither the time nor the cause of their erection; I say it may be conjectured that they were erected but a short time after the flood. It is not very likely, therefore, that the marine substances found in one of them, had time to be formed into a part of the solid stone, either during the deluge, or immediately after it; and, consequently, their petrefaction must have been before that period. And this is the opinion Mr. Buffon has so strenuously endeavoured to maintain; having given specious reasons to prove, that such shells were laid in the beds where they are now found, not only before the deluge, but even antecedent to the formation of man, at the time when the whole earth, as he supposes, was buried beneath a covering of waters.

But while there are many reasons to persuade us that these extraneous fossils have been deposited by the sea, there is one fact that will

abundantly ſerve to convince us that the earth was habitable, if not inhabited, before theſe marine ſubſtances came to be thus depoſited; for we find foſſil-trees, which no doubt once grew upon the earth, as deep, and as much in the body of ſolid rocks, as theſe ſhells are found to be. Some of theſe fallen trees alſo have lain at leaſt as long, if not longer, in the earth, than the ſhells, as they have been found ſunk deep in a marly ſubſtance, compoſed of decayed ſhells, and other marine productions. Mr. Buffon has proved that foſſil-ſhells could not have been depoſited in ſuch quantities all at once by the flood; and I think, from the above inſtance, it is pretty plain, that howſoever they were depoſited, the earth was covered with trees before their depoſition; and, conſequently, that the ſea could not have made a very permanent ſtay. How then ſhall we account for theſe extaraordinary appearances in nature? A ſuſpenſion of all aſſent is certainly the firſt, although the moſt mortifying conduct. For my own part, were I to offer a conjecture, and all that has been ſaid upon this ſubject is but conjecture, inſtead of ſuppoſing them to be the remains of animals belonging to the ſea, I would conſider them rather as bred in the numerous freſh-water lakes

that, in primæval times, covered the face of uncultivated nature. Some of these shells we know to belong to fresh waters: some can be assimilated to none of the marine shells now known*; why, therefore, may we not as well ascribe the production of all to fresh waters, where we do not find them, as we do that of the latter to the sea only, where we never find them? We know that lakes, and lands also, have produced animals that are now no longer existing; why, therefore, might not these fossil productions be among the number? I grant that this is making a very harsh supposition; but I cannot avoid thinking, that it is not attended with so many embarrassments as some of the former; and that it is much easier to believe that these shells were bred in fresh water, than that the sea had for a long time covered the tops of the highest mountains.

* Hill's Fossils, p. 641.

CHAP. VI.

Of the internal Structure of the Earth.

HAVING, in ſome meaſure, got free from the regions of conjecture, let us now proceed to a deſcription of the earth as we find it by examination, and obſerve its internal compoſition, as far as it has been the ſubject of experience, or expoſed to human enquiry. Theſe enquiries, indeed, have been carried but to a very little depth below its ſurface, and even in that diſquiſition men have been conducted more by motives of avarice than of curioſity. The deepeſt mine, which is that at Cotteberg in Hungary *, reaches not more than three thouſand feet deep; but what proportion does that bear to the depth of the terreſtrial globe, down to the centre, which is above four thouſand miles? All, therefore, that has been ſaid of the earth, to a deeper degree, is merely fabulous or conjectural: we may ſuppoſe with one, that it is a globe of glaſs †; with another, a ſphere of heated iron ‡; with

* Boyle, vol. iii. p. 240. † Buffon. ‡ Whiſton.

that, in primæval times, covered the face of uncultivated nature. Some of theſe ſhells we know to belong to freſh waters: ſome can be aſſimilated to none of the marine ſhells now known*; why, therefore, may we not as well aſcribe the production of all to freſh waters, where we do not find them, as we do that of the latter to the ſea only, where we never find them? We know that lakes, and lands alſo, have produced animals that are now no longer exiſting; why, therefore, might not theſe foſſil productions be among the number? I grant that this is making a very harſh ſuppoſition; but I cannot avoid thinking, that it is not attended with ſo many embarraſſments as ſome of the former; and that it is much eaſier to believe that theſe ſhells were bred in freſh water, than that the ſea had for a long time covered the tops of the higheſt mountains.

* Hill's Foſſils, p. 641.

CHAP. VI.

Of the internal Structure of the Earth.

HAVING, in some measure, got free from the regions of conjecture, let us now proceed to a description of the earth as we find it by examination, and observe its internal composition, as far as it has been the subject of experience, or exposed to human enquiry. These enquiries, indeed, have been carried but to a very little depth below its surface, and even in that disquisition men have been conducted more by motives of avarice than of curiosity. The deepest mine, which is that at Cotteberg in Hungary *, reaches not more than three thousand feet deep; but what proportion does that bear to the depth of the terrestrial globe, down to the centre, which is above four thousand miles? All, therefore, that has been said of the earth, to a deeper degree, is merely fabulous or conjectural: we may suppose with one, that it is a globe of glass †; with another, a sphere of heated iron ‡; with

* Boyle, vol. iii. p. 240. † Buffon. ‡ Whiston.

a third, a great mafs of waters *; and with a fourth, one dreadful volcano †; but let us, at the fame time, fhew our confcioufnefs, that all thefe are but fuppofitions.

Upon examining the earth, where it has been opened to any depth, the firft thing that occurs, is the different layers or beds of which it is compofed; thefe all lying horizontally one over the other like the leaves of a book, and each of them compofed of materials that encreafe in weight in proportion as they lie deeper. This is, in general, the difpofition of the different materials where the earth feems to have remained unmolefted; but this order is frequently inverted; and we cannot tell whether from its original formation, or from accidental caufes. Of different fubftances, thus difpofed, the far greateft part of our globe confifts, from its furface downwards to the greateft depths we ever dig or mine ‡.

The firft layer moft commonly found at the furface, is that light coat of blackifh mold, which is called, by fome, garden earth. With this the earth is every where invefted, unlefs it be wafhed off by rains, or removed by fome other external violence. This feems to have been formed from animal and vegetable

* Burnet. † Kircher. ‡ Woodward, p. 9.

bodies decaying, and thus turning into its ſubſtance. It alſo ſerves again as a ſtore-houſe, from whence animal and vegetable nature are renewed; and thus are all vital bleſſings continued with unceaſing circulation. This earth, however, is not to be ſuppoſed entirely pure, but is mixed with much ſtony and gravelly matter, from the layers lying immediately beneath it. It generally happens, that the ſoil is fertile in proportion to the quantity that this putrified mold bears to the gravelly mixture; and as the former predominates, ſo far is the vegetation upon it more luxuriant. It is this external covering that ſupplies man with all the true riches he enjoys. He may bring up gold and jewels from greater depths; but they are merely the toys of a capricious being, things upon which he has placed an imaginary value, and for which fools alone part with the more ſubſtantial bleſſings of life. It is this earth, ſays Pliny *, that, like a kind mother, receives us at our birth, and ſuſtains us when born. It is this alone, of all the elements around us, that is never found an enemy to man. The body of waters deluge him with rains, oppreſs him with hail, and drown him with inundations. The air ruſhes in ſtorms,

* Plin. Hiſt. Nat. lib. 2. cap. 63.

prepares the tempeſt, or lights up the volcano; but the earth, gentle and indulgent, ever ſubſervient to the wants of man, ſpreads his walks with flowers, and his table with plenty; returns with intereſt every good committed to her care; and, though ſhe produces the poiſon, ſhe ſtill ſupplies the antidote; though conſtantly teized more to furniſh the luxuries of man than his neceſſities, yet, even to the laſt, ſhe continues her kind indulgence, and, when life is over, ſhe piouſly covers his remains in her boſom.

This external and fruitful layer which covers the earth, is, as was ſaid, in a ſtate of continual change. Vegetables, which are naturally fixed and rooted to the ſame place, receive their adventitious nouriſhment from the ſurrounding earth and water: animals, which change from place to place, are ſupported by theſe, or by each other. Both, however, having for a time enjoyed a life adapted to their nature, give back to the earth thoſe ſpoils, which they had borrowed for a very ſhort ſpace, yet ſtill to be quickened again into freſh exiſtence. But the depoſits they make are of very diſſimilar kinds, and the earth is very differently enriched by their continuance. Thoſe countries that have for a long time ſupported men and other animals, having been obſerved to become every day more

barren, while, on the contrary, thofe defolate places, in which vegetables only are abundantly produced, are known to be poffeffed of amazing fertility. * "In regions which are uninhabited," fays Mr. Buffon, "where the forefts are not cut down, and where animals do not feed upon the plants, the bed of vegetable earth is conftantly encreafing. In all woods, and even in thofe often cut, there is a layer of earth of fix or eight inches thick, which has been formed by the leaves, branches and bark, which fall and rot upon the ground. I have frequently obferved on a Roman way which croffes Burgundy for a long extent, that there is a bed of black earth, of more than a foot thick, gathered over the ftony pavement, on which feveral trees, of a very confiderable fize, are fupported. This I have found to be nothing elfe than an earth formed by decayed leaves and branches, which have been converted by time into a black foil. Now as vegetables draw much more of their nourifhment from the air and water than they do from the earth, it muft follow, that in rotting upon the ground, they muft give more to the foil than they have taken from it. Hence, therefore, in woods kept a long time without cutting, the foil below

* Buffon, vol. i. p. 353.

encreaſes to a conſiderable depth; and ſuch we actually find the ſoil in thoſe American wilds where the foreſts have been undiſturbed for ages. But it is otherwiſe where men and animals have long ſubſiſted; for as they make a conſiderable conſumption of wood and plants, both for firing and other uſes, they take more from the earth than they return to it: it follows, therefore, that the bed of vegetable earth, in an inhabited country, muſt be always diminiſhing; and muſt, at length, reſemble the ſoil of Arabia Petrea, and other provinces of the Eaſt, which having been long inhabited, are now become plains of ſalt and ſand; the fixed ſalt always remaining while the other volatile parts have flown away."

If from this external ſurface we deſcend deeper, and view the earth cut perpendicularly downwards, either in the banks of great rivers, or ſteepy ſea ſhores; or, going ſtill deeper, if we obſerve it in quarries or mines, we ſhall find its layers regularly diſpoſed in their proper order. We muſt not expect, however, to find them of the ſame kind or thickneſs in every place, as they differ in different ſoils and ſituations. Sometimes marle is ſeen to be over ſand, and ſometimes under it. The moſt common diſpoſition is, that under the firſt earth

is found gravel or ſand, then clay or marle, then chalk or coal, marbles, oars, ſands, gravels; and thus an alternation of theſe ſubſtances, each growing more denſe as it ſinks deeper. The clay, for inſtance, found at the depth of an hundred feet, is uſually more heavy than that found not far from the ſurface. In a well which was dug at Amſterdam, to the depth of two hundred and thirty feet, the following ſubſtances were found in ſucceſſion *: ſeven feet of vegetable earth, nine of turf, nine of ſoft clay, eight of ſand, four of earth, ten of clay, four of earth, ten of ſand, two of clay, four of white ſand, one of ſoft earth, fourteen of ſand, eight of clay mixed with ſand, four of ſea-ſand mixed with ſhells, then an hundred and two feet of ſoft clay, and then thirty-one feet of ſand.

In a well dug at Marly, to the depth of an hundred feet, Mr. Buffon gives us a ſtill more exact enumeration of its layers of earth. Thirteen of a redish gravel, two of gravel mingled with a vitrifiable ſand, three of mud or ſlime, two of marle, four of marly ſtone, five of marle in duſt mixed with vitrifiable ſand, ſix of very fine vitrifiable ſand, three of earthy marle, three of hard marle, one of gravel, one of

* Varenius, as quoted by Mr. Buffon, p. 358.

eglantine, a ſtone of the hardneſs and grain of marble, one of gravelly marle, one of ſtony marle, one of a coarſer kind of ſtony marle, two of a coarſer kind ſtill, one of vitrifiable ſand mixed with foſſil ſhells, two of fine gravel, three of ſtony marle, one of coarſe powdered marle, one of ſtone, calcinable like marble, three of grey ſand, two of white ſand, one of red ſand ſtreaked with white, eight of grey ſand with ſhells, three of very fine ſand, three of a hard grey ſtone, four of red ſand ſtreaked with white, three of white ſand, and fifteen of rediſh vitrifiable ſand.

In this manner the earth is every where found in beds over beds; and, what is ſtill remarkable, each of them, as far as it extends, always maintains exactly the ſame thickneſs. It is found alſo, that, as we proceed to conſiderable depths, every layer grows thicker. Thus in the adduced inſtances we might have obſerved, that the laſt layer was fifteen feet thick, while moſt of the others were not above eight; and this might have gone much deeper, for aught we can tell, as before they got through it the workmen ceaſed digging.

Theſe layers are ſometimes very extenſive, and often are found to cover a ſpace of ſome leagues in circumference. But it muſt

not be ſuppoſed that they are uniformly continued over the whole globe without any interruption: on the contrary, they are ever, at ſmall intervals, cracked through as it were by perpendicular fiſſures; the earth reſembling, in this reſpect, the muddy bottom of a pond, from whence the water has been dried off by the ſun, and thus gaping in ſeveral chinks, which deſcend in a direction perpendicular to its ſurface. Theſe fiſſures are many times found empty, but oftener cloſed up with adventitious ſubſtances, that the rain, or ſome other accidental cauſes, have conveyed to fill their cavities. Their openings are not leſs different than their contents, ſome being not above half an inch wide, ſome a foot, and ſome ſeveral hundred yards aſunder; which laſt form thoſe dreadful chaſms that are to be found in the Alps, at the edge of which the traveller ſtands, dreading to look down at the immeaſurable gulph below. Theſe amazing clefts are well known to ſuch as have paſt theſe mountains, where a chaſm frequently preſents itſelf ſeveral hundred feet deep, and as many over, at the edge of which the way lies. It often happens alſo, that the road leads along the bottom, and then the ſpectator obſerves on each ſide frightful precipices ſeveral hundred

yards above him; the sides of which correspond so exactly with each other, that they evidently seem torn asunder.

But these chasms to be found in the Alps, are nothing to what Ovalle tells us are to be seen in the Andes. These amazing mountains, in comparison of which the former are but little hills, have their fissures in proportion to their greatness. In some places they are a mile wide, and deep in proportion; and there are some others, that running underground, in extent resemble a province.

Of this kind also is that cavern called Elden-hole, in Derbyshire; which, Dr. Plot tells us, was founded by a line of eight and twenty hundred feet, without finding the bottom, or meeting with water: and yet the mouth at the top is not above forty yards over *. This immeasureable cavern runs perpendicularly downward; and the sides of it seem to tally so plainly as to shew that they once were united. Those who come to visit the place, generally procure stones to be thrown into its mouth; and these are heard for several minutes, falling and striking against the sides of the cavern, producing a sound that resembles distant thunder, dying away as the stone goes deeper.

* Phil. Trans. vol. ii. p. 370.

Of this kind alſo is that dreadful cavern deſcribed by Ælian; his account of which the reader may not have met with *. "In the country of the Arrian Indians, is to be ſeen an amazing chaſm, which is called, The Gulph of Pluto. The depth, and the receſſes of this horrid place, are as extenſive as they are unknown. Neither the natives, nor the curious who viſit it, are able to tell how it firſt was made, or to what depths it deſcends. The Indians continually drive thither great multitudes of animals, more than three thouſand at a time, of different kinds, ſheep, horſes, and goats; and, with an abſurd ſuperſtition, force them into the cavity, from whence they never return. Their ſeveral ſounds, however, are heard as they deſcend; the bleating of ſheep, the lowing of oxen, and the neighing of horſes, iſſuing up to the mouth of the cavern. Nor do theſe ſounds ceaſe, as the place is continually furniſhed with a freſh ſupply."

There are many more of theſe dreadful perpendicular fiſſures in different parts of the earth; with accounts of which Kircher, Gaffarellus, and others, who have given hiſtories of the wonders of the ſubterranean world, abundantly ſupply us. The generality of readers, however, will conſider them with leſs aſtoniſhment, when they are informed of their being common all

* Æliani Var. Hiſt. lib. xvi. cap. 16.

over the earth: that in every field, in every quarry, theſe perpendicular fiſſures are to be found; either ſtill gaping, or filled with matter that has accidentally cloſed their interſtices. The inattentive ſpectator neglects the enquiry, but their being common is partly the cauſe that excites the philoſopher's attention to them: the irregularities of nature he is often content to let paſs unexamined; but when a conſtant and a common appearance preſents itſelf, every return of the object is a freſh call to his curioſity; and the chink in the next quarry becomes as great a matter of wonder as the chaſm in Elden-hole. Philoſophers have long, therefore, endeavoured to find out the cauſe of theſe perpendicular fiſſures, which our own countrymen, Woodward and Ray, were the firſt that found to be ſo common and univerſal. Mr. Buffon ſuppoſes them to be cracks made by the ſun, in drying up the earth immediately after its emerſion from the deep. The heat of the ſun is very probably a principal cauſe; but it is not right to aſcribe to one only, what we find may be the reſult of many. Earthquakes, ſevere froſts, burning waters, and ſtorms tearing up the roots of trees, have, in our own times, produced them: and to this variety of cauſes we muſt, at preſent, be content to aſſign thoſe that have happened before we had opportunities for obſervation.

CHAP. VII.

Of Caves and ſubterraneous Paſſages that ſink, but not perpendicularly, into the Earth.

In ſurveying the ſubterranean wonders of the globe, beſides thoſe fiſſures that deſcend perpendicularly, we frequently find others that deſcend but a little way, and then ſpread themſelves often to a great extent below the ſurface. Many of theſe caverns, it muſt be confeſſed, may be the production of art and human induſtry; retreats made to protect the oppreſſed, or ſhelter the ſpoiler. The famous labyrinth of Candia, for inſtance, is ſuppoſed to be entirely the work of art. Mr. Tournefort aſſures us, that it bears the impreſſion of human induſtry, and that great pains have been beſtowed upon its formation. The ſtone-quarry of Maeſtricht is evidently made by labour: carts enter at its mouth, and load within, then return and diſcharge their freight into boats that lie on the brink of the river Maeſe. This quarry is ſo large, that forty thouſand people may take ſhelter in it: and it in general ſerves for this purpoſe, when armies march that way; becoming then an impregnable retreat to the people

that live thereabout. Nothing can be more beautiful than this cavern, when lighted up with torches; for there are thouſands of ſquare pillars, in large level walks, about twenty feet high; and all wrought with much neatneſs and regularity. In this vaſt grotto there is very little rubbiſh; which ſhews both the goodneſs of the ſtone, and the carefulneſs of the workmen. To add to its beauty, there alſo are, in various parts of it, little pools of water, for the convenience of the men and cattle. It is remarkable alſo, that no droppings are ſeen to fall from the roof, nor are the walks any way wet under foot, except in caſes of great rains, where the water gets in by the air-ſhafts. The Salt-mines in Poland are ſtill more ſpacious than theſe. Some of the catacombs, both in Egypt and Italy, are ſaid to be very extenſive. But no part of the world has a greater number of artificial caverns than Spain, which were made to ſerve as retreats to the Chriſtians, againſt the fury of the Moors, when the latter conquered that country. However, an account of the works of art does not properly belong to a natural hiſtory. It will be ſufficient to obſerve, that though caverns be found in every country, far the greateſt part of them have been faſhioned by the hand of Nature only. Their ſize is found beyond the

power of man to have effected; and their forms but ill adapted to the conveniences of an human habitation. In ſome places, indeed, we find mankind ſtill make uſe of them as houſes; particularly in thoſe countries where the climate is very ſevere *; but in general they are deſerted by every race of meaner animals, except the bat: theſe nocturnal ſolitary creatures are uſually the only inhabitants; and theſe only in ſuch whoſe deſcent is ſloping, or, at leaſt, not directly perpendicular.

There is ſcarce a country in the world without its natural caverns; and many new ones are diſcovered every day. Of thoſe in England, Oakey-hole, the Devil's-hole, and Penpark-hole, have been often deſcribed. The former, which lies on the ſouth ſide of Mendip-hills †, within a mile of the town of Wells, is much reſorted to by travellers. To conceive a juſt idea of this, we muſt imagine a precipice of more than an hundred yards high, on the ſide of a mountain which ſhelves away a mile above it. In this is an opening not very large, into which you enter, going along upon a rocky uneven pavement, ſometimes aſcending, and ſometimes deſcending. The roof of it, as you advance, grows higher; and, in ſome places, is fifty feet

* Phil. Tranſ. vol. ii. p. 368. † Ibid.

from the floor. In ſome places, however, it is ſo low that a man muſt ſtoop to paſs. It extends itſelf, in length, about two hundred yards; and from every part of the roof, and the floor, there are formed ſparry concretions of various figures, that by ſtrong imaginations have been likened to men, lions, and organs. At the fartheſt part of this cavern riſes a ſtream of water, well ſtored with fiſh, large enough to turn a mill, and which diſcharges itſelf near the entrance.

Penpark-hole, in Glouceſterſhire, is almoſt as remarkable as the former. Captain Sturmey deſcended into this by a rope, twenty-five fathoms perpendicular, and at the bottom found a very large vault in the ſhape of an horſe-ſhoe. The floors conſiſted of a kind of white ſtone enamelled with lead ore, and the pendent rocks were glazed with ſpar. Walking forward on this ſtony pavement, for ſome time, he came to a great river, twenty fathoms broad, and eight fathoms deep; and having been informed that it ebbed and flowed with the ſea, he remained in his gloomy abode for five hours, to make an exact obſervation. He did not find, however, any alteration whatſoever in its appearance. But his curioſity was ill requited; for it coſt this unfortunate gentleman his life: immediately

after his return, he was ſeized with an unuſual and violent head-ach, which threw him into a fever, of which he died ſoon after.

But of all the ſubterraneous caverns now known, the grotto of Antiparos is the moſt remarkable, as well for its extent, as for the beauty of its ſparry incruſtations. This celebrated cavern was firſt diſcovered by one Magni, an Italian traveller, about an hundred years ago, at Antiparos, an inconſiderable iſland of the Archipelago *. The account he gives of it is long and inflated, but upon the whole amuſing. "Having been informed," ſays he, "by the natives of Paros, that in the little iſland of Antiparos, which lies about two miles from the former, of a gigantic ſtatue that was to be ſeen at the mouth of a cavern in that place, it was reſolved that we (the French conſul and himſelf) ſhould pay it a viſit. In purſuance of this reſolution, after we had landed on the iſland, and walked about four miles through the midſt of beautiful plains, and ſloping woodlands, we at length came to a little hill, on the ſide of which yawned a moſt horrid cavern, that with its gloom at firſt ſtruck us with terror, and almoſt repreſſed cu-

* Kircher Mund. Subt. 112. I have tranſlated a part of Kircher's deſcription, rather than Tournefort's, as the latter was written to ſupport an hypotheſis.

riosity. Recovering the first surprize, however, we entered boldly; and had not proceeded above twenty paces, when the supposed statue of the giant presented itself to our view. We quickly perceived, that what the ignorant natives had been terrified at as a giant, was nothing more than a sparry concretion, formed by the water dropping from the roof of the cave, and by degrees hardening into a figure that their fears had formed into a monster. Incited by this extraordinary appearance, we were induced to proceed still farther, in quest of new adventures in this subterranean abode. As we proceeded, new wonders offered themselves; the spars, formed into trees and shrubs, presented a kind of petrified grove; some white, some green; and all receding in due perspective. They struck us with the more amazement, as we knew them to be mere productions of Nature, who, hitherto in solitude, had, in her playful moments, dressed the scene, as if for her own amusement.

"But we had as yet seen but a few of the wonders of the place; and we are introduced only into the portico of this amazing temple. In one corner of this half illuminated recess, there appeared an opening of about three feet wide, which seemed to lead to a place to-

tally dark, and that one of the natives aſſured us contained nothing more than a reſervoir of water. Upon this we tried, by throwing down ſome ſtones, which rumbling along the ſides of the deſcent for ſome time, the ſound ſeemed at laſt quaſhed in a bed of water. In order, however, to be more certain, we ſent in a Levantine mariner, who, by the promiſe of a good reward, with a flambeaux in his hand, ventured into this narrow aperture. After continuing within it for about a quarter of an hour, he returned, carrying ſome beautiful pieces of white ſpar in his hand, which art could neither imitate nor equal. Upon being informed by him that the place was full of theſe beautiful incruſtations, I ventured in once more with him, for about fifty paces, anxiouſly and cautiouſly deſcending by a ſteep and dangerous way. Finding, however, that we came to a precipice which led into a ſpacious amphitheatre, if I may ſo call it, ſtill deeper than any other part, we returned, and being provided with a ladder, flambeaux, and other things to expedite our deſcent, our whole company, man by man, ventured into the ſame opening, and deſcending one after another, we at laſt ſaw ourſelves all together in the moſt magnificent part of the cavern.

"Our candles being now all lighted up, and the whole place completely illuminated, never could the eye be presented with a more glittering, or a more magnificent scence. The roof all hung with solid isicles, transparent as glass, yet solid as marble. The eye could scarce reach the lofty and noble cieling; the sides were regularly formed with spars; and the whole presented the idea of a magnificent theatre, illuminated with an immense profusion of lights. The floor consisted of solid marble; and in several places, magnificent columns, thrones, altars, and other objects appeared, as if nature had designed to mock the curiosities of art. Our voices, upon speaking or singing, were redoubled to an astonishing loudness; and upon the firing of a gun, the noise and reverberations were almost deafening. In the midst of this grand amphitheatre rose a concretion of about fifteen feet high, that, in some measure, resembled an altar; from which, taking the hint, we caused mass to be celebrated there. The beautiful columns that shot up round the altar, appeared like candlesticks; and many other natural objects represented the customary ornaments of this sacrament.

"Below even this spacious grotto, there seemed another cavern; down which I ventured with

my former mariner, and defcended about fifty paces by means of a rope. I at laft arrived at a fmall fpot of level ground, where the bottom appeared different from that of the amphitheatre, being compofed of foft clay, yielding to the preffure, and in which I thruft a ftick to about fix feet deep. In this, however, as above, numbers of the moft beautiful chryftals were formed; one of which, particularly, refembled a table. Upon our egrefs from this amazing cavern, we perceived a Greek infcription upon a rock at the mouth, but fo obliterated by time, that we could not read it. It feemed to import that one Antipater, in the time of Alexander, had come thither; but whether he penetrated into the depths of the cavern, he does not think fit to inform us."

Such is the account of this beautiful fcene, as communicated in a letter to Kircher. We have another, and a more copious defcription of it by Tournefort, which is in every body's hands; but I have given the above, both becaufe it was communicated by the firft difcoverer, and becaufe it is a fimple narrative of facts, without any reafoning upon them. According to Tournefort's account, indeed, we might conclude, from the rapid growth of the fpars in this grotto, that it muft every year be growing

narrower, and that it muſt, in time, be choaked up with them entirely; but no ſuch thing has happened hitherto, and the grotto at this day continues as ſpacious as we ever knew it.

This is not a place for an enquiry into the ſeeming vegetation of thoſe ſtony ſubſtances with which this and almoſt every cavern are incruſted. It is enough to obſerve, in general, that they are formed by an accumulation of that little gritty matter which is carried thither by the waters, and which in time acquires the hardneſs of marble. What in this place more imports us to know is, how theſe amazing hollows in the earth came to be formed. And I think, in the three inſtances above-mentioned, it is pretty evident, that their excavation has been owing to water. Theſe finding ſubterraneous paſſages under the earth, and by long degrees hollowing the beds in which they flowed, the ground above them has ſlipt down cloſer to their ſurface, leaving the upper layers of the earth or ſtone ſtill ſuſpended. The ground that ſinks upon the face of the waters forming the floor of the cavern; the ground, or rock that keeps ſuſpended, forming the roof: and, indeed, there are but few of theſe caverns found without water, either within them, or near enough to point out their formation.

CHAP. VIII.

Of Mines, Damps, and Mineral Vapours.

THE caverns, which we have been defcribing, generally carry us but a very little way below the furface of the earth. Two hundred feet, at the utmoft, is as much as the loweft of them is found to fink. The perpendicular fiffures run much deeper; but few perfons have been bold enough to venture down to their deepeft receffes: and fome few who have tried, have been able to bring back no tidings of the place, for unfortunately they left their lives below. The excavations of art have conducted us much farther into the bowels of the globe. Some mines in Hungary are known to be a thoufand yards perpendicular downwards; and I have been informed, by good authority, of a coal-mine in the north of England, an hundred yards deeper ftill.

It is befide our prefent purpofe to enquire into the peculiar conftruction and contrivance of thefe, which more properly belongs to the hiftory of foffils. It will be fufficient to obferve in this place, that as we defcend into the

mines, the various layers of earth are ſeen, as we have already deſcribed them; and in ſome of theſe are always found the metals or minerals, for which the mine has been dug. Thus frequently gold is found diſperſed and mixed with clay and gravel *; ſometimes it is mingled with other metallic bodies, ſtones, or bitumens; and † ſometimes united with that moſt obſtinate of all ſubſtances, platina, from which ſcarce any art can ſeparate it. Silver is ſometimes found quite pure ‡, ſometimes mixed with other ſubſtances and minerals. Copper is found in beds mixed with various ſubſtances, marbles, ſulphurs, and pyrites. Tin, the ore of which is heavier than that of any other metal, is generally found mixed with every kind of matter: § lead is alſo equally common; and iron we well know can be extracted from all the ſubſtances upon earth.

The variety of ſubſtances which are thus found in the bowels of the earth, in their native ſtate, have a very different appearance from what they are afterwards taught to aſſume by human induſtry. The richeſt metals are very often leſs glittering and ſplendid than the moſt

* Ulloa, vol. ii. p. 470. † Ulloa, ibid.
‡ Macquer's Chymiſtry, vol. i. p. 316.
§ Hill's Foſſils, p. 628.

ufelefs marcafites, and the bafeft ores are in general the moft beautiful to the eye.

This variety of fubftances, which compofe the internal parts of our globe, is productive of equal varieties both above and below its furface. The combination of the different minerals with each other, the heats which arife from their mixture, the vapours they diffufe, the fires which they generate, or the colds which they fometimes produce, are all either noxious or falutary to man; fo that in this great elaboratory of nature, a thoufand benefits and calamities are forging, of which we are wholly unconfcious; and it is happy for us that we are fo.

* Upon our defcent into mines of confiderable depth, the cold feems to encreafe from the mouth as we defcend; but after paffing very low down, we begin, by degrees, to come into a warmer air, which fenfibly grows hotter as we go deeper, till, at laft, the labourers can fcarce bear any covering as they continue working.

This difference in the air was fuppofed by Boyle to proceed from magazines of fire that lay nearer the centre, and that diffufed their heat to the adjacent regions. But we now

* Boyle, vol. iii. p. 232.

know that it may be aſcribed to more obvious cauſes. In ſome mines, the compoſition of the earth all around is of ſuch a nature, that upon the admiſſion of water or air, it frequently becomes hot, and often burſts out into eruptions. Beſides this, as the external air cannot readily reach the bottom, or be renewed there, an obſervable heat is perceived below, without the neceſſity of recurring to the central heat for an explanation.

Hence, therefore, there are two principal cauſes of the warmth at the bottom of mines: the heat of the ſubſtances of which the ſides are compoſed; and the want of renovation in the air below. Any ſulphureous ſubſtance mixed with iron, produces a very great heat, by the admiſſion of water. If, for inſtance, a quantity of ſulphur be mixed with a proportionable ſhare of iron filings, and both kneaded together into a ſoft paſte, with water, they will ſoon grow hot, and at laſt produce a flame. This experiment, produced by art, is very commonly effected within the bowels of the earth by nature. Sulphurs and irons are intimately blended together, and want only the mixture of water or air to excite their heat; and this, when once raiſed, is communicated to all bodies that lie within the ſphere of their operation. Thoſe beautiful

minerals called marcaſites and pyrites, are often of this compoſition; and wherever they are found, either by imbibing the moiſture of the air, or having been by any means combined with water, they render the mine conſiderably hot *.

The want of freſh air, alſo, at theſe depths, is, as we have ſaid, another reaſon for their being found much hotter. Indeed, without the aſſiſtance of art, the bottom of moſt mines would, from this cauſe, be inſupportable. To remedy this inconvenience, the miners are often obliged to ſink, at ſome convenient diſtance from the mouth of the pit where they are at work, another pit, which joins the former below, and which, in Derbyſhire, is called an air-ſhaft. Through this the air circulates; and thus the workmen are enabled to breathe freely at the bottom of the place; which becomes, as Mr. Boyle affirms, very commodious for reſpiration; and alſo very temperate as to heat and cold †. Mr. Locke, however, who has left us an account of the Mendip mines, ſeems to preſent a different picture. "The deſcent into theſe is exceeding difficult and dangerous; for they are not ſunk like wells, perpendicularly,

* Kircher Mund. Subt. vol. ii. p. 216.

† Boyle, vol. iii. p. 238.

but as the crannies of the rocks happen to run. The conſtant method is to ſwing down by a rope, placed under the arms, and clamber along, by applying both feet and hands to the ſides of the narrow paſſage. The air is conveyed into them through a little paſſage that runs along the ſides from the top, where they ſet up ſome turfs, on the lee-ſide of the hole, to catch and force it down. Theſe turfs being removed to the windy ſide, or laid over the mouth of the hole, the miners below preſently want breath, and faint; and if ſweet-ſmelling flowers chance to be placed there, they immediately loſe their fragrancy, and ſtink like carrion." An air ſo very putrifying can never be very commodious for reſpiration.

Indeed, if we examine the complexion of moſt miners, we ſhall be very well able to form a judgment of the unwholeſomeneſs of the place where they are confined. Their pale and ſallow looks ſhew how much the air is damaged by paſſing through thoſe deep and winding ways, that are rendered humid by damps, or warmed with noxious exhalations. But although every mine is unwholeſome, all are not equally ſo. Coal-mines are generally leſs noxious than thoſe of tin; tin than thoſe of copper; but none are ſo dreadfully deſtructive as thoſe of quickſilver.

At the mines near the village of Idra, nothing can adequately defcribe the deplorable infirmities of fuch as fill the hofpital there: emaciated and crippled, every limb contracted or convulfed, and fome in a manner tranfpiring quickfilver at every pore. There was one man, fays Dr. Pope *, who was not in the mines above half a year, and yet whofe body was fo impregnated with this mineral, that putting a piece of brafs money in his mouth, or rubbing it between his fingers, it immediately became as white as if it had been wafhed over with quickfilver. In this manner all the workmen are killed, fooner or later; firft becoming paralytic, and then dying confumptive: and all this they fuftain for the trifling reward of feven-pence a day.

But thefe metallic mines are not fo noxious from their own vapours, as from thofe of the fubftances with which the ores are ufually united, fuch as arfenic, cinnabar, bitumen, or vitriol. From the fumes of thefe, varioufly combined, and kept enclofed, are produced thofe various damps that put on fo many dreadful forms, and are ufually fo fatal. Sometimes thofe noxious vapours are perceived by the delightful fragrance of their fmell †, fomewhat refembling the pea-bloffom in bloom, from whence

* Phil. Tranf. vol. ii. p. 578. † Ibid. p. 375.

one kind of damp has its name. The miners are not deceived, however, by its flattering appearances; but as they have thus timely notice of its coming, they avoid it while it continues, which is generally during the whole fummer feafon. Another fhews its approach by the burning of the candles, which feem to collect their flame into a globe of light, and thus gradually leffen, till they are quite extinguifhed. From this alfo the miners frequently efcape; however, fuch as have the misfortune to be caught in it, either fwoon away, and are fuffocated, or flowly recover in exceffive agonies. Here alfo is a third, called the fulminating damp, much more dangerous than either of the former, as it ftrikes down all before it, like a flafh of gunpowder, without giving any warning of its approach. But there is another, more dangerous than all the reft, which is found in thofe places where the vapour has been long confined, and has been, by fome accident, fet free. The air rufhing out from thence, always goes upon deadly errands; and fcarce any efcape to defcribe the fymptoms of its operations.

Some colliers in Scotland, working near an old mine that had been long clofed up, happened inadvertently to open an hole into it, from the pit where they were then employed.

By great good fortune, they at that time perceived their error, and inftantly fled for their lives. The next day, however, they were refolved to renew their work in the fame pit, and eight of them ventured down, without any great apprehenfions; but they had fcarce got to the bottom of the ftairs that led to the pit, but coming within the vapour, they all inftantly dropped down dead, as if they had been fhot. Amongft thefe unfortunate poor men, there was one whofe wife was informed that he was ftifled in the mine; and as he happened to be next the entrance, fhe fo far ventured down as to fee where he lay. As fhe approached the place, the fight of her hufband infpired her with a defire to refcue him, if poffible, from that dreadful fituation; though a little reflection might have fhewn her it was then too late. But nothing could deter her; fhe ventured forward, and had fcarce touched him with her hand, when the damp prevailed, and the mifguided, but faithful creature, fell dead by his fide.

Thus, the vapours found beneath the furface of the earth, are very various in their effects upon the conftitution: and they are not lefs in their appearances. There are many kinds that feemingly are no way prejudicial to health, but in which the workmen breathe freely; and yet

in these, if a lighted candle be introduced, they immediately take fire, and the whole cavern at once becomes one furnace of flame. In mines, therefore, subject to damps of this kind, they are obliged to have recourse to a very peculiar contrivance to supply sufficient light for their operations. This is by a great wheel; the circumference of which is beset with flints, which striking against steels placed for that purpose at the extremity, a stream of fire is produced, which affords light enough; and yet which does not set fire to the mineral vapour.

Of this kind are the vapours of the mines about Bristol: on the contrary, in other mines, a single spark struck out from the collision of flint and steel, would set the whole shaft in a flame. In such, therefore, every precaution is used to avoid a collision; the workmen making use only of wooden instruments in digging; and being cautious before they enter the mine, to take out even the nails from their shoes. Whence this strange difference should arise, that the vapours of some mines catch fire with a spark, and others only with a flame, is a question that we must be content to leave in obscurity, till we know more of the nature both of mineral vapour and of fire. This only we may observe, that gunpowder will readily fire

with a ſpark, but not with the flame of a candle: on the other hand, ſpirits of wine will flame with a candle, but not with a ſpark; but even here the cauſe of this difference, as yet, remains a ſecret.

As from this account of mines, it appears that the internal parts of the globe are filled with vapours of various kinds, it is not ſurpriſing, that they ſhould at different times reach the ſurface, and there put on various appearances. In fact, much of the ſalubrity, and much of the unwholſomeneſs of climates and ſoils, is to be aſcribed to theſe vapours, which make their way from the bowels of the earth upwards, and refreſh or taint the air with their exhalations. Salt mines being naturally cold *, ſend forth a degree of coldneſs to the external air, to comfort and refreſh it: on the contrary, metallic mines are known, not only to warm it with their exhalations, but often to deſtroy all kinds of vegetation by their volatile corroſive fumes. In ſome mines denſe vapours are plainly perceived iſſuing from their mouths, and ſenſibly warm to the touch. In ſome places, neither ſnow nor ice will continue on the ground that covers a mine; and over others

* Phil. Tranſ. vol. ii. p. 523.

the fields are found deftitute of verdure *. The inhabitants, alfo, are rendered dreadfully fenfible of thefe fubterraneous exhalations, being affected with fuch a variety of evils proceeding entirely from this caufe, that books have been profeffedly written upon this clafs of diforders.

Nor are thefe vapours which thus efcape to the furface of the earth, entirely unconfined; for they are frequently, in a manner circumfcribed to a fpot: the grotto Del Cane, near Naples, is an inftance of this; the noxious effects of which have made that cavern fo very famous. This grotto, which has fo much employed the attention of travellers, lies within four miles of Naples, and is fituated near a large lake of clear and wholefome water †. Nothing can exceed the beauty of the landfcape which this lake affords; being furrounded with hills covered with forefts of the moft beautiful verdure, and the whole bearing a kind of amphitheatrical appearance. However, this region, beautiful as it appears, is almoft entirely uninhabited; the few peafants that neceffity compels to refide there, looking quite confumptive and ghaftly, from the poifonous exhala-

* Boyle, vol. iii. p. 238.

† Kircher, Mund. Subt. vol. i. p. 191.

tions that riſe from the earth. The famous grotto lies on the ſide of an hill, near which place a peaſant reſides, who keeps a number of dogs for the purpoſe of ſhewing the experiment to the curious. Theſe poor animals always ſeem perfectly ſenſible of the approach of a ſtranger, and endeavour to get out of the way. However, their attempts being perceived, they are taken and brought to the grotto; the noxious effects of which they have ſo frequently experienced. Upon entering this place, which is a little cave, or rather a hole dug into the hill, about eight feet high and twelve feet long, the obſerver can ſee no viſible marks of its peſtilential vapour; only to about a foot from the bottom, the wall ſeems to be tinged with a colour reſembling that which is given by ſtagnant waters. When the dog, this poor philoſophical martyr, as ſome have called him, is held above this mark, he does not ſeem to feel the ſmalleſt inconvenience; but when his head is thruſt down lower, he ſtruggles to get free for a little; but in the ſpace of four or five minutes he ſeems to loſe all ſenſation, and to be taken out without life. Being plunged in the neighbouring lake, he quickly recovers, and is permitted

to run home seemingly without the smallest injury.

This vapour, which thus for a time suffocates, is of the humid kind, as it extinguishes a torch, and sullies a looking-glass; but there are other vapours perfectly inflammable, and that only require the approach of a candle to set them blazing. Of this kind was the burning well at Brosely, which is now stopped up; the vapour of which, when a candle was brought within about a foot of the surface of the water, caught flame like spirits of wine, and continued blazing for several hours after. Of this kind, also, are the perpetual fires in the kingdom of Persia. In that province, where the worshippers of fire hold their chief mysteries, the whole surface of the earth, for some extent, seems impregnated with inflammable vapours. A reed stuck into the ground continues to burn like a flambeaux; an hole made beneath the surface of the earth, instantly becomes a furnace answering all the purposes of a culinary fire. There they make lime by merely burying the stones in the earth, and watch with veneration the appearances of a flame that has not been extinguished for times immemorial. How different are men in various

A Volcano.

C. Martin sculp.

climates! This deluded people worſhip theſe vapours as a deity, which in other parts of the world are conſidered as one of the greateſt evils.

CHAP. IX.

Of Volcanoes and Earthquakes.

MINES and caverns, as we have ſaid, reach but a very little way under the ſurface of the earth, and we have hitherto had no opportunities of exploring further. Without all doubt the wonders that are ſtill unknown ſurpaſs thoſe that have been repreſented, as there are depths of thouſands of miles which are hidden from our enquiry. The only tidings we have from thoſe unfathomable regions are by means of volcanoes, thoſe burning mountains that ſeem to diſcharge their materials from the loweſt abyſſes of the earth*. A volcano may be conſidered as a cannon of immenſe ſize, the mouth of which is often near two miles in circumference. From this dreadful aperture are diſcharged torrents of flame and ſulphur, and

* Buffon, vol. i. p. 291.

rivers of melted metal. Whole clouds of ſmoke and aſhes, with rocks of enormous ſize, are diſcharged to many miles diſtance; ſo that the force of the moſt powerful artillery is but as a breeze agitating a feather, in compariſon. In the deluge of fire and melted matter which runs down the ſides of the mountain, whole cities are ſometimes ſwallowed up and conſumed. Thoſe rivers of liquid fire are often two hundred feet deep; and, when they harden, frequently form conſiderable hills. Nor is the danger of theſe confined to the eruption only: but the force of the internal fire ſtruggling for vent, frequently produces earthquakes through the whole region where the volcano is ſituated. So dreadful have been theſe appearances, that men's terrors have added new horrors to the ſcene, and they have regarded as prodigies, what we know to be the reſult of natural cauſes. Some philoſophers have conſidered them as vents communicating with the fires of the center, and the ignorant as the mouths of hell itſelf. Aſtoniſhment produces fear, and fear ſuperſtition: the inhabitants of Iceland believe the bellowings of Hecla are nothing elſe but the cries of the damned, and that its eruptions are contrived to encreaſe their tortures.

But if we regard this aſtoniſhing ſcene of terror with a more tranquil and inquiſitive eye, we ſhall find that theſe conflagrations are produced by very obvious and natural cauſes. We have already been apprized of the various mineral ſubſtances in the boſom of the earth, and their aptneſs to burſt out into flames. Marcaſites and pyrites, in particular, by being humefied with water, or air, contract this heat, and often endeavour to expand with irreſiſtible exploſion. Theſe, therefore, being lodged in the depths of the earth, or in the boſom of mountains, and being either waſhed by the accidental influx of waters below, or fanned by air, inſinuating itſelf through perpendicular fiſſures from above, take fire at firſt by only heaving in earthquakes, but at length by burſting through every obſtacle, and making their dreadful diſcharge in a volcano.

Theſe volcanoes are found in all parts of the earth: in Europe there are three that are very remarkable; Ætna in Sicily, Veſuvius in Italy, and Hecla in Iceland. Ætna has been a volcano for ages immemorial. Its eruptions are very violent, and its diſcharge has been known to cover the earth ſixty-eight feet deep. In the year 1537, an eruption of this mountain produced an earthquake through the whole iſland,

for twelve days, overturned many houses, and at last formed a new aperture which overwhelmed all within five leagues round. The cinders thrown up were driven even into Italy, and its burnings were seen at Malta, at the distance of sixty leagues. There is nothing more awful, says Kircher, than the eruptions of this mountain, nor nothing more dangerous than attempting to examine its appearances, even long after the eruption has ceased. As we attempt to clamber up its steepy sides, every step we take upward, the feet sink back half way. Upon arriving near the summit, ashes and snow, with an ill assorted conjunction, present nothing but objects of desolation. Nor is this the worst, for, as all places are covered over, many caverns are entirely hidden from the sight, into which, if the enquirer happens to fall, he sinks to the bottom, and meets inevitable destruction. Upon coming to the edge of the great crater, nothing can sufficiently represent the tremendous magnificence of the scene. A gulph two miles over, and so deep that no bottom can be seen; on the sides pyramidical rocks starting out between apertures that emit smoke and flame; all this accompanied with a sound that never ceases, louder than thunder, strikes the bold with horror, and the religious with vene-

ration for him that has power to control its burnings.

In the deſcriptions of Veſuvius, or Hecla, we ſhall find ſcarce any thing but a repetition of the ſame terrible objects, though rather leſſened, as theſe mountains are not ſo large as the former. The crater of Veſuvius is but a mile acroſs, according to the ſame author; whereas that of Ætna is two. On this particular, however, we muſt place no dependance, as theſe caverns every day alter; being leſſened by the mountains ſinking in at one eruption, and enlarged by the fury of another. It is not one of the leaſt remarkable particulars reſpecting Veſuvius, that Pliny the naturaliſt was ſuffocated in one of its eruptions; for his curioſity impelling him too near, he found himſelf involved in ſmoke and cinders when it was too late to retire; and his companions hardly eſcaped to give an account of the miſfortune. It was in that dreadful eruption that the city of Herculaneum was overwhelmed; the ruins of which have been lately diſcovered at ſixty feet diſtance below the ſurface, and, what is ſtill more remarkable, forty feet below the bed of the ſea. One of the moſt remarkable eruptions of this mountain was in the year 1707, which is finely deſcribed by Valetta, a part of

whose description I shall beg leave to translate.

"Towards the latter end of summer, in the year 1707, the mount Vesuvius, that had for a long time been silent, now began to give some signs of commotion. Little more than internal murmurs at first were heard, that seemed to contend within the lowest depths of the mountain; no flame, nor even any smoak, was as yet seen. Soon after some smoak appeared by day, and a flame by night, which seemed to brighten all the Campania. At intervals also it shot off substances with a sound very like that of artillery, but which, even at so great a distance as we were at, infinitely exceeded them in greatness. Soon after it began to throw up ashes, which becoming the sport of the winds, fell at great distances, and some many miles. To this succeeded showers of stones, which killed many of the inhabitants of the valley, but made a dreadful ravage among the cattle. Soon after a torrent of burning matter began to roll down the sides of the mountain, at first with a slow and gentle motion, but soon with encreased celerity. The matter thus poured out, when cool, seemed, upon inspection, to be of vitrified earth, the whole united into a mass of more than stony hardness. But what

was particularly obfervable was, that upon the whole furface of thefe melted materials, a light fpongy ftone feemed to float, while the lower body was of the hardeft fubftance, of which our roads are ufually made. Hitherto there were no appearances but what had been often remarked before; but on the third or fourth day, feeming flafhes of lightning were fhot forth from the mouth of the mountain, with a noife far exceeding the loudeft thunder. Thefe flafhes, in colour and brightnefs, refembled what we ufually fee in tempefts, but they affumed a more twifted and ferpentine form. After this followed fuch clouds of fmoak and afhes, that the whole city of Naples, in the midft of the day, was involved in nocturnal darknefs, and the neareft friends were unable to diftinguifh each other in this frightful gloom. If any perfon attempted to ftir out without torch-light, he was obliged to return, and every part of the city was filled with fupplications and terror; at length, after a continuance of fome hours, about one o'clock at midnight, the wind blowing from the north, the ftars began to be feen; the heavens, though it was night, began to grow brighter; and the eruptions, after a continuance of fifteen days, to leffen. The torrent of melted matter was feen to extend from

the mountain down to the ſhore; the people began to return to their former dwellings, and the whole face of nature to reſume its former appearance."

Biſhop Berkley gives an account of one of theſe eruptions in a manner ſomething different from the former. * "In the year 1717, and the middle of April, with much difficulty I reached the top of mount Veſuvius, in which I ſaw a vaſt aperture full of ſmoak, which hindered me from ſeeing its depth and figure. I heard within that horrid gulph certain extraordinary ſounds, which ſeemed to proceed from the bowels of the mountain, a ſort of murmuring, ſighing, daſhing ſound, and between whiles a noiſe like that of thunder or cannon, with a clattering like that of tiles falling from the tops of houſes into the ſtreets. Sometimes, as the wind changed, the ſmoak grew thinner, diſcovering a very ruddy flame, and the circumference of the crater ſtreaked with red and ſeveral ſhades of yellow. After an hour's ſtay, the ſmoak being moved by the wind, gave us ſhort and partial proſpects of the great hollow; in the flat bottom of which I could diſcern two furnaces almoſt contiguous; that on the left ſeeming about three yards

* Phil. Tranſ. vol. ii. p. 209.

over, glowing with ruddy flame, and throwing up red hot ſtones, with an hideous noiſe, which, as they fell back, cauſed the clattering already taken notice of. May 8, in the morning, I aſcended the top of Veſuvius a ſecond time, and found a different face of things. The ſmoak aſcending upright, gave a full proſpect of the crater, which, as I could judge, was about a mile in circumference, and an hundred yards deep. A conical mount had been formed ſince my laſt viſit in the middle of the bottom, which I could ſee was made by the ſtones, thrown up and fallen back again into the crater. In this new hill remained the two furnaces already mentioned. The one was ſeen to throw up every three or four minutes, with a dreadful ſound, a vaſt number of red hot ſtones, at leaſt three hundred feet higher than my head, as I ſtood upon the brink; but as there was no wind, they fell perpendicularly back from whence they had been diſcharged. The other was filled with red hot liquid matter, like that in the furnace of a glaſs-houſe; raging and working like the waves of the ſea, with a ſhort abrupt noiſe. This matter would ſometimes boil over, and run down the ſide of the conical hill, appearing at firſt red hot, but changing colour as it hardened and cooled. Had the

wind driven in our faces, we had been in no ſmall danger of ſtifling by the ſulphureous ſmoak, or being killed by the maſſes of melted minerals, that were ſhot from the bottom. But as the wind was favourable, I had an opportunity of ſurveying this amazing ſcene for above an hour and an half together. On the fifth of June, after an horrid noiſe, the mountain was ſeen at Naples to work over; and about three days after, its thunders were renewed ſo, that not only the windows in the city, but all the houſes ſhook. From that time it continued to overflow, and ſometimes at night were ſeen columns of fire ſhooting upward from its ſummit. On the tenth, when all was thought to be over, the mountain again renewed its terrors, roaring and raging moſt violently. One cannot form a juſter idea of the noiſe, in the moſt violent fits of it, than by imagining a mixed ſound, made up of the raging of a tempeſt, the murmur of a troubled ſea, and the roaring of thunder and artillery, confuſed all together. Though we heard this at the diſtance of twelve miles, yet it was very terrible. I therefore reſolved to approach nearer to the mountain; and, accordingly, three or four of us got into a boat, and were ſet aſhore at a little town, ſituated at the foot of the mountain. From thence we rode

about four or five miles, before we came to the torrent of fire that was defcending from the fide of the volcano; and here the roaring grew exceeding loud and terrible as we approached. I obferved a mixture of colours in the cloud, above the crater, green, yellow, red, blue. There was likewife a ruddy difmal light in the air, over that tract where the burning river flowed. Thefe circumftances, fet off and augmented by the horror of the night, made a fcene the moft uncommon and aftonifhing I ever faw; which ftill encreafed as we approached the burning river. Imagine a vaft torrent of liquid fire, rolling from the top, down the fide of the mountain, and with irrefiftible fury bearing down and confuming vines, olives, and houfes; and divided into different channels, according to the inequalities of the mountain. The largeft ftream feemed half a mile broad at leaft, and five miles long. I walked fo far before my companions up the mountain, along the fide of the river of fire, that I was obliged to retire in great hafte, the fulphureous fteam having furprifed me, and almoft taken away my breath. During our return, which was about three o'clock in the morning, the roaring of the mountain was heard all the way, while we obferved it throwing up huge fpouts of fire and

burning ſtones, which falling, reſembled the ſtars in a rocket. Sometimes I obſerved two or three diſtinct columns of flame, and ſometimes one only that was large enough to fill the whole crater. Theſe burning columns, and fiery ſtones, ſeemed to be ſhot a thouſand feet perpendicular above the ſummit of the volcano: and in this manner the mountain continued raging for ſix or eight days after. On the eighteenth of the ſame month the whole appearance ended, and the mountain remained perfectly quiet, without any viſible ſmoke or flame."

The matter which is found to roll down from the mouth of all volcanoes in general, reſembles the droſs that is thrown from a ſmith's forge. But it is different, perhaps, in various parts of the globe; for, as we have already ſaid, there is not a quarter of the world that has not its volcanoes. In Aſia, particularly in the iſlands of the Indian ocean, there are many. One of the moſt famous is that of Albouras, near Mount Taurus, the ſummit of which is continually on fire, and covers the whole adjacent country with aſhes. In the iſland of Ternate there is a volcano, which ſome travellers aſſert, burns moſt furiouſly in the times of the equinoxes, becauſe of the winds which

then contribute to encreafe the flames. In the Molucca iflands there are many burning mountains; they are alfo feen in Japan, and the iflands adjacent; and in Java and Sumatra, as well as in other of the Philippine iflands. In Africa there is a cavern, near Fez, which continually fends forth either fmoke or flames. In the Cape de Verde iflands, one of them, called the Ifland del Fuego, continually burns; and the Portuguefe, who frequently attempted a fettlement there, have as often been obliged to defift. The Peak of Teneriffe is, as every body knows, a volcano that feldom defifts from eruptions. But of all parts of the earth, America is the place where thofe dreadful irregularities of nature are the moft confpicuous. Vefuvius, and Ætna itfelf, are but mere fireworks, in comparifon to the burning mountains of the Andes; which, as they are the higheft mountains of the world, fo alfo are they the moft formidable for their eruptions. The mountain of Arequipa in Peru, is one of the moft celebrated; Caraffa, and Malahallo, are very confiderable; but that of Cotopaxi, in the province of Quito, exceeds any thing we have hitherto read or heard of. The mountain of Cotopaxi, as defcribed by Ulloa *, is more

* Ulloa, vol. i. p. 442.

than three miles perpendicular from the sea; and it became a volcano at the time of the Spaniards' firſt arrival in that country. A new eruption of it happened in the year 1743, having been ſome days preceded by a continual roaring in its bowels. The ſound of one of theſe mountains is not like that of the volcanoes in Europe, confined to a province, but is heard at an hundred and fifty miles diſtance *. "An aperture was made in the ſummit of this immenſe mountain; and three more about equal heights, near the middle of its declivity, which was at that time buried under prodigious maſſes of ſnow. The ignited ſubſtances ejected on that occaſion, mixed with a prodigious quantity of ice and ſnow, melting amidſt the flames, were carried down with ſuch aſtoniſhing rapidity, that in an inſtant the valley from Callo to Latacunga was overflowed; and beſides its ravages in bearing down the houſes of the Indians, and other poor inhabitants, great numbers of people loſt their lives. The river of Latacunga was the channel of this terrible flood; till being too ſmall for receiving ſuch a prodigious current, it overflowed the adjacent country, like a vaſt lake, near the town, and carried away all the buildings within its reach. The inhabitants re-

* Ulloa, vol. i. p. 442.

tired into a ſpot of higher ground behind the town, of which thoſe parts which ſtood within the limits of the current were totally deſtroyed. The dread of ſtill greater devaſtations did not ſubſide for three days; during which, the volcano ejected cinders, while torrents of melted ice and ſnow poured down its ſides. The eruption laſted ſeveral days, and was accompanied with terrible roarings of the wind, ruſhing through the volcano ſtill louder than the former rumblings in its bowels. At laſt all was quiet, neither fire nor ſmoke to be ſeen, nor noiſe to be heard; till, in the enſuing year, the flames again appeared with recruited violence, forcing their paſſage through ſeveral other parts of the mountain, ſo that in clear nights the flames being reflected by the tranſparent ice, formed an awfully magnificent illumination."

Such is the appearance and the effect of thoſe fires which proceed from the more inward receſſes of the earth; for that they generally come from deeper regions than man has hitherto explored, I cannot avoid thinking, contrary to the opinion of Mr. Buffon, who ſuppoſes them rooted but a very little way below the bed of the mountain. We can never ſuppoſe, ſays this great naturaliſt, that theſe ſubſtances are ejected

from any great diſtance below, if we only conſider the great force already required to fling them up to ſuch vaſt heights above the mouth of the mountain; if we conſider the ſubſtances thrown up, which we ſhall find upon inſpection to be the ſame with thoſe of the mountain below; if we take into our conſideration, that air is always neceſſary to keep up the flame; but, moſt of all, if we attend to one circumſtance, which is, that if theſe ſubſtances were exploded from a vaſt depth below, the ſame force required to ſhoot them up ſo high, would act againſt the ſides of the volcano, and tear the whole mountain in pieces. To all this ſpecious reaſoning, particular anſwers might eaſily be given; as that the length of the funnel encreaſes the force of the exploſion; that the ſides of the funnel are actually often burſt with the great violence of the flame; that air may be ſuppoſed at depths at leaſt as far as the perpendicular fiſſures deſcend. But the beſt anſwer is a well-known fact; namely, that the quantity of matter diſcharged from Ætna alone, is ſuppoſed, upon a moderate computation, to exceed twenty times the original bulk of the mountain *. The greateſt part of Sicily ſeems covered with its eruptions.

* Kircher, Mund. Subt. vol. i. p. 202.

The inhabitants of Catanea have found, at the diſtance of ſeveral miles, ſtreets and houſes, ſixty feet deep, overwhelmed by the lava or matter it has diſcharged. But what is ſtill more remarkable, the walls of theſe very houſes have been built of materials evidently thrown up by the mountain. The inference from all this is very obvious; that the matter thus exploded cannot belong to the mountain itſelf, otherwiſe, it would have been quickly conſumed; it cannot be derived from moderate depths, ſince its amazing quantity evinces, that all the places near the bottom muſt have long ſince been exhauſted; nor can it have an extenſive, and, if I may ſo call it, a ſuperficial ſpread, for then the country round would be quickly undermined; it muſt, therefore, be ſupplied from the deeper regions of the earth; thoſe undiſcovered tracts where the Deity performs his wonders in ſolitude, ſatisfied with ſelf-approbation!

THE TANJORE * MAHAL

CHAP. X.

Of Earthquakes.

HAVING given the theory of volcanoes, we have in ſome meaſure given alſo that of earthquakes. They both ſeem to proceed from the ſame cauſe, only with this difference, that the fury of the volcano is ſpent in the eruption, that of an earthquake ſpreads wider and acts more fatally by being confined. The volcano only affrights a province, earthquakes have laid whole kingdoms in ruin.

Philoſophers * have taken ſome pains to diſtinguiſh between the various kinds of earthquakes, ſuch as the tremulous, the pulſative, the perpendicular, and the inclined; but theſe are rather the diſtinctions of art than of nature, mere accidental differences ariſing from the ſituation of the country or of the cauſe. If, for inſtance, the confined fire acts directly under a province or a town, it will heave the earth perpendicularly upward, and produce a *perpendicular* earthquake. If it acts at a diſtance, it

* Ariſtotle, Agricola, Buffon.

will raife that tract obliquely, and thus the inhabitants will perceive an *inclined* one.

Nor does it feem to me that there is much greater reafon for Mr. Buffon's diftinction of earthquakes. One kind of which he fuppofes* to be produced by fire in the manner of volcanoes, and confined but to a very narrow circumference. The other kind he afcribes to the ftruggles of confined air, expanded by heat in the bowels of the earth, and endeavouring to get free. For how do thefe two caufes differ? Fire is an agent of no power whatfoever without air. It is the air, which being at firft compreffed, and then dilated in a cannon, that drives the ball with fuch force. It is the air ftruggling for vent in a volcano, that throws up its contents to fuch vaft heights. In fhort, it is the air confined in the bowels of the earth, and acquiring elafticity by heat, that produces all thofe appearances generally afcribed to the operation of fire. When, therefore, we are told that there are two caufes of earthquakes, we only learn, that a greater or fmaller quantity of heat produces thofe terrible effects; for air is the only active operator in either.

Some philofophers, however, have been willing to give the air as great a fhare in produc-

* Buffon, vol. ii. p. 328.

ing these terrible efforts as they could; and, magnifying its powers, have called in but a very moderate degree of heat to put it in action. Although experience tells us that the earth is full of inflammable materials, and that fires are produced wherever we descend; although it tells us that those countries, where there are volcanoes, are most subject to earthquakes, yet they step out of the way, and so find a new solution. These only allow but just heat enough to produce the most dreadful phœnomena, and backing their assertions with long calculations, give theory an air of demonstration. Mr. Amontons* has been particularly sparing of the internal heat in this respect; and has shewn, perhaps accurately enough, that a very moderate degree of heat may suffice to give the air amazing powers of expansion.

It is astonishing, however, to trace the progress of a philosophical fancy let loose in imaginary speculations. They run thus: "A very moderate degree of heat may bring the air into a condition capable of producing earthquakes; for the air at the depth of forty-three thousand five hundred and twenty-eight fathom below the surface of the earth, becomes almost as heavy

* Memoires de l' Académie de Sciences. An. 1703.

as quickſilver. This, however, is but a very ſlight depth in compariſon of the diſtance to the center, and is ſcarce a ſeventieth part of the way. The air, therefore, at the center muſt be infinitely heavier than mercury, or any body that we know of. This granted, we ſhall take ſomething more, and ſay, that it is very probable there is nothing but air at the center. Now let us ſuppoſe this air heated, by ſome means, even to the degree of boiling water, as we have proved that the denſity of the air is here very great, its elaſticity muſt be in proportion: an heat, therefore, which at the ſurface of the earth would have produced but a ſlight expanſive force, muſt at the center produce one very extraordinary, and, in ſhort, be perfectly irreſiſtible. Hence this force may with great eaſe produce earthquakes; and if encreaſed it may convulſe the globe; it may (by only adding figures enough to the calculation) deſtroy the ſolar ſyſtem, and even the fixed ſtars themſelves." Theſe reveries generally produce nothing; for, as I have ever obſerved, encreaſed calculations, while they ſeem to tire the memory, give the reaſoning faculty perfect repoſe.

However, as earthquakes are the moſt formidable miniſters of nature, it is not to be

wondered that a multitude of writers have been curiously employed in their consideration. Woodward has ascribed the cause to a stoppage of the waters below the earth's surface, by some accident. These being thus accumulated, and yet acted upon by fires, which he supposes still deeper, both contribute to heave up the earth upon their bosom. This he thinks accounts for the lakes of water produced in an earthquake, as well as for the fires that sometimes burst from the earth's surface upon those dreadful occasions. There are others who have supposed that the earth may be itself the cause of its own convulsions. When, say they, the roots or basis of some large tract is worn away by a fluid underneath, the earth sinking therein, its weight occasions a tremor of the adjacent parts, sometimes producing a noise, and sometimes an inundation of water. Not to tire the reader with an history of opinions instead of facts, some have ascribed them to electricity, and some to the same causes that produce thunder.

It would be tedious, therefore, to give all the various opinions that have employed the speculative upon this subject. The activity of the internal heat seems alone sufficient to account for every appearance that attends these

tremendous irregularities of nature. To conceive this diftinctly, let us fuppofe at fome vaft diftance under the earth, large quantities of inflammable matter, pyrites, bitumens, and marcafites difpofed, and only waiting for the afperfion of water, or the humidity of the air, to put their fires in motion; at laft, this dreadful mixture arrives; waters find their way into thofe depths, through the perpendicular fiffures; or air infinuates itfelf through the fame minute apertures; immediately new appearances enfue: thofe fubftances, which for ages before lay dormant, now conceive new apparent qualities; they grow hot, produce new air, and only want room for expanfion. However, the narrow apertures by which the air or water had at firft admiffion, are now clofed up; yet as new air is continually generated, and as the heat every moment gives this air new elafticity, it at length burfts, and dilates all round; and, in its ftruggles to get free, throws all above it into fimilar convulfions. Thus an earthquake is produced, more or lefs extenfive, according to the depth or the greatnefs of the caufe.

But before we proceed with the caufes, let us take a fhort view of the appearances which have attended the moft remarkable earthquakes. By thefe we fhall fee how far the

theorist corresponds with the historian. The greatest we find in antiquity, is that mentioned by Pliny *, in which twelve cities in Asia Minor were swallowed up in one night: he tells us also of another, near the lake Thrasymene, which was not perceived by the armies of the Carthaginians and Romans, that were then engaged near that lake, although it shook the greatest part of Italy. In another place † he gives the following account of an earthquake of an extraordinary kind. "When Lucius Marcus, and Sextus Julius, were consuls, there appeared a very strange prodigy of the earth, (as I have read in the books of Ætruscan discipline) which happened in the province of Mutina. Two mountains shocked against each other, approaching and retiring with the most dreadful noise. They, at the same time, and in the midst of the day, appeared to cast forth fire and smoke, while a vast number of Roman knights and travellers from the Æmilian way, stood and continued amazed spectators. Several towns were destroyed by this shock; and all the animals that were near them were killed." In the times of Trajan, the city of Antioch, and a great part of the adjacent country, was buried by an earthquake. About

* Plin. lib. ii. cap. 86. † Ibid. lib. iii. cap. 85.

three hundred years after, in the times of Juftinian, it was once more deftroyed, together with forty thoufand inhabitants: and, after an interval of fixty years, the fame ill-fated city was a third time overturned, with the lofs of not lefs than fixty thoufand fouls. In the year 1182, moft of the cities of Syria, and the kingdom of Jerufalem, were deftroyed by the fame accident. In the year 1594, the Italian hiftorians defcribe an earthquake at Puteoli, which caufed the fea to retire two hundred yards from its former bed.

But one of thofe moft particularly defcribed in hiftory, is that of the year 1693; the damages of which were chiefly felt in Sicily, but its motion perceived in Germany, France, and England. It extended to a circumference of two thoufand fix hundred leagues; chiefly affecting the fea-coafts, and great rivers; more perceivable alfo upon the mountains than in the valleys. Its motions were fo rapid, that thofe who lay at their length, were toffed from fide to fide, as upon a rolling billow *. The walls were dafhed from their foundations; and no lefs than fifty-four cities, with an incredible number of villages, were either deftroyed or greatly damaged. The city of Catanea, in particular,

* Phil. Tranf.

was utterly overthrown. A traveller, who was on his way thither, at the diftance of fome miles, perceived a black cloud, like night, hanging over the place. The fea, all of a fudden, began to roar; Mount Ætna to fend forth great fpires of flame; and foon after a fhock enfued, with a noife as if all the artillery in the world had been at once difcharged. Our traveller, being obliged to alight inftantly, felt himfelf raifed a foot from the ground; and turning his eyes to the city, he with amazement faw nothing but a thick cloud of duft in the air. The birds flew about aftonifhed; the fun was darkened; the beafts ran howling from the hills; and, although the fhock did not continue above three minutes, yet near nineteen thoufand of the inhabitants of Sicily perifhed in the ruins. Catanea, to which city the defcriber was travelling, feemed the principal fcene of ruin; its place only was to be found, and not a footftep of its former magnificence was to be feen remaining.

The earthquake which happened in Jamaica, in 1692, was very terrible, and its defcription fufficiently minute. "In two minutes time it deftroyed the town of Port-Royal, and funk the houfes in a gulph forty fathoms deep. It was attended with an hollow rumbling noife, like

that of thunder; and, in lefs than a minute, three parts of the houfes, and their inhabitants, were all funk quite under water. While they were thus fwallowed up on one fide of the ftreet, on the other, the houfes were thrown into heaps; the fand of the ftreet rifing like the waves of the fea, lifting up thofe that ftood upon it, and immediately overwhelming them in pits. All the wells difcharged their waters with the moft vehement agitation. The fea felt an equal fhare of turbulence, and, burfting over its mounds, deluged all that came in its way. The fiffures of the earth were, in fome places, fo great, that one of the ftreets appeared twice as broad as formerly. In many places, however, it opened and clofed again, and continued this agitation for fome time. Of thefe openings, two or three hundred might be feen at a time; in fome whereof the people were fwallowed up; in others, the earth clofing, caught them by the middle, and thus crufhed them inftantly to death. Other openings, ftill more dreadful than the reft, fwallowed up whole ftreets; and others, more formidable, fpouted up whole cataracts of water, drowning fuch as the earthquake had fpared. The whole was attended with the moft noifome ftench; while the thundering of the diftant falling mountains, the whole fky overcaft

with a dusky gloom, and the crash of falling habitations, gave unspeakable horror to the scene. After this dreadful calamity was over, the whole island seemed converted into a scene of desolation; scarce a planter's house was left standing; almost all were swallowed up; houses, people, trees, shared one universal ruin; and, in their places appeared great pools of water, which, when dried up by the sun, left only a plain of barren sand, without any vestige of former inhabitants. Most of the rivers, during the earthquake, were stopt up by the falling in of the mountains; and it was not till after some time that they made themselves new channels. The mountains seemed particularly attacked by the force of the shock; and it was supposed that the principal seat of the concussion was among them. Those who were saved, got on board ships in the harbour; where many remained above two months, the shocks continuing during that interval with more or less violence every day."

As this description seems to exhibit all the appearances that usually make up the catalogue of terrors belonging to an earthquake, I will suppress the detail of that which happened at Lisbon, in our own times, and which is too recent to require a description. In fact, there are

few particulars in the accounts of thefe who were prefent at that fcene of defolation, that we have not more minutely and accurately tranf-mitted to us by former writers, whofe nar-ratives I have for that reafon preferred. I will, therefore, clofe this defcription of human cala-mities, with the account of the dreadful earth-quake at Calabria, in 1638. It is related by the celebrated Father Kircher, as it happend while he was on his journey to vifit Mount Ætna, and the reft of the wonders that lie towards the fouth of Italy. I need fcarce inform the reader that Kircher is confidered, by fcholars, as one of the greateft prodigies of learning.

" Having hired a boat, in company with four more, two friars of the order of St. Francis, and two feculars, we launched, on the twenty-fourth of March, from the harbour of Meffina, in Sicily, and arrived, the fame day, at the pro-montory of Pelorus. Our deftination was for the city of Euphæmia, in Calabria, where we had fome bufinefs to tranfact, and where we defigned to tarry for fome time. However, Providence feemed willing to crofs our defign; for we were obliged to continue for three days at Pelorus, upon account of the weather; and though we often put out to fea, yet we were as often driven back. At length, however, wea-

ried with the delay, we resolved to prosecute our voyage; and, although the sea seemed more than usually agitated, yet we ventured forward. The gulph of Charybdis, which we approached, seemed whirled round in such a manner, as to form a vast hollow, verging to a point in the center. Proceeding onward, and turning my eyes to Ætna, I saw it cast forth large volumes of smoke, of mountainous sizes, which entirely covered the whole island, and blotted out the very shores from my view. This, together with the dreadful noise, and the sulphureous stench, which was strongly perceived, filled me with apprehensions that some more dreadful calamity was impending. The sea itself seemed to wear a very unusual appearance; those who have seen a lake in a violent shower of rain covered all over with bubbles, will conceive some idea of its agitations. My surprize was still encreased by the calmness and serenity of the weather; not a breeze, not a cloud which might be supposed to put all Nature thus into motion. I therefore warned my companions that an earthquake was approaching; and, after some time, making for the shore with all possible diligence, we landed at Tropæa, happy and thankful for having escaped the threatening dangers of the sea.

"But our triumphs at land were of ſhort duration; for we had ſcarce arrived at the Jeſuits College in that city, when our ears were ſtunned with an horrid ſound, reſembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking. Soon after this, a moſt dreadful earthquake enſued; ſo that the whole tract upon which we ſtood ſeemed to vibrate, as if we were in the ſcale of a balance that continued wavering. This motion, however, ſoon grew more violent; and being no longer able to keep my legs, I was thrown proſtrate upon the ground. In the mean time, the univerſal ruin round me redoubled my amazement. The craſh of falling houſes, the tottering of towers, and the groans of the dying, all contributed to raiſe my terror and deſpair. On every ſide of me I ſaw nothing but a ſcene of ruin; and danger threatening wherever I ſhould fly. I commended myſelf to God as my laſt great refuge. At that hour, O how vain was every ſublunary happineſs! wealth, honour, empire, wiſdom, all mere uſeleſs ſounds, and as empty as the bubbles in the deep. Juſt ſtanding on the threſhold of eternity, nothing but God was my pleaſure; and the nearer I approached, I only loved him the more. After ſome time, how-

ever, finding that I remained unhurt, amidſt the general concuſſion, I reſolved to venture for ſafety, and running as faſt as I could, reached the ſhore, but almoſt terrified out of my reaſon. I did not ſearch long here till I found the boat in which I had landed, and my companions alſo, whoſe terrors were even greater than mine. Our meeting was not of that kind where every one is deſirous of telling his own happy eſcape; it was all ſilence, and a gloomy dread of impending terrors.

"Leaving this ſeat of deſolation, we proſecuted our voyage along the coaſt; and the next day came to Rochetta, where we landed, although the earth ſtill continued in violent agitations. But we were ſcarce arrived at our inn, when we were once more obliged to return to the boat; and, in about half an hour, we ſaw the greateſt part of the town, and the inn at which we had ſet up, daſhed to the ground, and burying all its inhabitants beneath its ruins.

"In this manner, proceeding onward in our little veſſel, finding no ſafety at land, and yet, from the ſmallneſs of our boat, having but a very dangerous continuance at ſea, we at length landed at Lopizium, a caſtle midway between Tropæa and Euphemia, the city to which, as I

ſaid before, we were bound. Here, wherever I turned my eyes, nothing but ſcenes of ruin and horror appeared; towns and caſtles levelled to the ground; Strombalo, though at ſixty miles diſtance, belching forth flames in an unuſual manner, and with a noiſe which I could diſtinctly hear. But my attention was quickly turned from more remote to contiguous danger. The rumbling ſound of an approaching earthquake, which we by this time were grown acquainted with, alarmed us for the conſequences; it every moment ſeemed to grow louder, and to approach more near. The place on which we ſtood now began to ſhake moſt dreadfully; ſo that being unable to ſtand, my companions and I caught hold of whatever ſhrub grew next us, and ſupported ourſelves in that manner.

"After ſome time, this violent paroxyſm ceaſing, we again ſtood up, in order to proſecute our voyage to Euphæmia, that lay within ſight. In the mean time, while we were preparing for this purpoſe, I turned my eyes towards the city, but could ſee only a frightful dark cloud, that ſeemed to reſt upon the place. This the more ſurpriſed us, as the weather was ſo very ſerene. We waited, therefore, till the cloud was paſt away: then turning to look for the city, it was totally ſunk. Wonderful to tell!

nothing but a dismal and putrid lake was seen where it stood. We looked about to find some one that could tell us of its sad catastrophe, but could see none. All was become a melancholy solitude; a scene of hideous desolation. Thus proceeding pensively along, in quest of some human being that could give us some little information, we at length saw a boy sitting by the shore, and appearing stupified with terror. Of him, therefore, we enquired concerning the fate of the city; but he could not be prevailed on to give us an answer. We entreated him with every expression of tenderness and pity to tell us; but his senses were quite wrapt up in the contemplation of the danger he had escaped. We offered him some victuals, but he seemed to loath the sight. We still persisted in our offices of kindness; but he only pointed to the place of the city, like one out of his senses; and then running up into the woods, was never heard of after. Such was the fate of the city of Euphæmia: and as we continued our melancholy course along the shore, the whole coast, for the space of two hundred miles, presented nothing but the remains of cities; and men scattered, without an habitation, over the fields. Proceeding thus along, we at length ended our distressful voyage by arriving at Naples, after

having eſcaped a thouſand dangers both at ſea and land."

The reader, I hope, will excuſe me for this long tranſlation from a favourite writer, and that the ſooner, as it contains ſome particulars relative to earthquakes not to be found elſewhere. From the whole of theſe accounts we may gather, that the moſt concomitant circumſtances are theſe:

A rumbling ſound before the earthquake. This proceeds from the air, or fire, or both, forcing their way through the chaſms of the earth, and endeavouring to get free, which is alſo heard in volcanoes.

A violent agitation, or heaving of the ſea, ſometimes before and ſometimes after that at land. This agitation is only a ſimilar effect produced on the waters with that at land, and may be called, for the ſake of perſpicuity, a ſea-quake; and this alſo is produced by volcanoes.

A ſpouting up of waters to great heights. It is not eaſy to deſcribe the manner in which this is performed; but volcanoes alſo perform the ſame, Veſuvius being known frequently to eject a vaſt body of water.

A rocking of the earth to and fro, and ſometimes a perpendicular bouncing, if it may be

ſo called, of the ſame. This difference chiefly ariſes from the ſituation of the place with reſpect to the ſubterranean fire. Directly under, it lifts; at a farther diſtance, it rocks.

Some earthquakes ſeem to travel onward, and are felt in different countries at different hours the ſame day. This ariſes from the great ſhock being given to the earth at one place, and that being communicated onward by an undulatory motion, ſucceſſively affects different regions in its progreſs; as the blow given by a ſtone falling in a lake is not perceived at the ſhores till ſome time after the firſt concuſſion.

The ſhock is ſometimes inſtantaneous, like the exploſion of gunpowder; and ſometimes tremulous, and continuing for ſeveral minutes. The nearer the place where the ſhock is firſt given, the more inſtantaneous and ſimple it appears. At a greater diſtance the earth redoubles the firſt blow, with a ſort of vibratory continuation.

As waters have generally ſo great a ſhare in producing earthquakes, it is not to be wondered that they ſhould generally follow thoſe breaches made by the force of fire, and appear in the great chaſms which the earthquake has opened.

Theſe are ſome of the moſt remarkable

phœnomena of earthquakes, preſenting a frightful aſſemblage of the moſt terrible effects of air, earth, fire, and water.

The valley of Solfatara, near Naples, ſeems to exhibit, in a minuter degree, whatever is ſeen of this horrible kind on the great theatre of Nature. This plain, which is about twelve hundred feet long, and a thouſand broad, is emboſomed in mountains, and has in the middle of it a lake of noiſome blackiſh water, covered with a bitumen, that floats upon its ſurface. In every part of this plain, caverns appear ſmoking with ſulphur, and often emitting flames. The earth, wherever we walk over it, trembles beneath the feet. Noiſes of flames, and the hiſſing of waters, are heard at the bottom. The water ſometimes ſpouts up eight or ten feet high. The moſt noiſome fumes, fœtid water, and ſulphureous vapours, offend the ſmell. A ſtone thrown into any of the caverns, is ejected again with conſiderable violence. Theſe appearances generally prevail when the ſea is any way diſturbed; and the whole ſeems to exhibit the appearance of an earthquake in miniature. However, in this ſmaller ſcene of wonders, as well as in the greater, there are many appearances for which perhaps we ſhall never account; and many queſtions may be aſked, which no conjectures

can thoroughly refolve. It was the fault of the philofophers of the laft age, to be more inquifitive after the caufes of things, than after the things themfelves. They feemed to think that a confeffion of ignorance cancelled their claims to wifdom: they, therefore, had a folution for every demand. But the prefent age has grown, if not more inquifitive, at leaft more modeft; and none are now afhamed of that ignorance which labour can neither remedy nor remove.

CHAP. XI.

Of the Appearance of New Iflands, and Tracts; and of the difappearing of others.

HITHERTO we have taken a furvey only of the evils which are produced by fubterranean fires, but we have mentioned nothing of the benefits they may poffibly produce. They may be of ufe in warming and cherifhing the ground, in promoting vegetation, and giving a more exquifite flavour to the productions of the earth. The imagination of a perfon who has never been out of our own mild region, can fcarcely reach to that luxuriant beauty with which all Nature appears cloathed in thofe very countries that we

have but just now described as desolated by earthquakes, and undermined by subterranean fires. It must be granted, therefore, that though in those regions they have a greater share in the dangers, they have also a larger proportion in the benefits of Nature.

But there is another advantage arising from subterranean fires, which, though hitherto disregarded by man, yet may one day become serviceable to him; I mean, that while they are found to swallow up cities and plains in one place, they are also known to produce promontories and islands in another. We have many instances of islands being thus formed in the midst of the sea, which though for a long time barren, have afterwards become fruitful seats of happiness and industry.

New islands are formed in two ways; either suddenly, by the action of subterraneous fires; or more slowly, by the deposition of mud, carried down by rivers, and stopped by some accident *. With respect particularly to the first, ancient historians, and modern travellers, give us such accounts as we can have no room to doubt of. Seneca assures us, that in his time the island of Therasia appeared unexpectedly to some mariners, as they were employed in

* Buffon, vol. ii. p. 343.

another purſuit. Pliny aſſures us, that thirteen iſlands in the Mediterranean appeared at once emerging from the water; the cauſe of which he aſcribes rather to the retiring of the ſea in thoſe parts, than to any ſubterraneous elevation. However, he mentions the iſland of Hiera, near that of Theraſia, as formed by ſubterraneous exploſions; and adds to his liſt ſeveral others, formed in the ſame manner. In one of which he relates that fiſh in great abundance were found, and that all thoſe who eat of them died ſhortly after.

"On the twenty-fourth of May *, in the year 1707, a ſlight earthquake was perceived at Santorin; and the day following, at ſun-riſing, an object was ſeen by the inhabitants of that iſland, at two or three miles diſtance at ſea, which appeared like a floating rock. Some perſons, deſirous either of gain, or excited by curioſity, went there, and found, even while they ſtood upon this rock, that it ſeemed to riſe beneath their feet. They perceived alſo that its ſurface was covered with pumice ſtones and oyſters, which it had raiſed from the bottom. Every day after, until the fourteenth of June, this rock ſeemed conſiderably to encreaſe; and then was found to be half a mile round, and

* Hiſt. de l'Acad. an. 1708, p. 23.

about thirty feet above the ſea. The earth of which it was compoſed ſeemed whitiſh, with a ſmall portion of clay. Soon after this the ſea again appeared troubled, and ſteams aroſe, which were very offenſive to the inhabitants of Santorin. But on the ſixteenth of the ſucceeding month, ſeventeen or eighteen rocks more were ſeen to riſe out of the ſea, and at length to join together. All this was accompanied with the moſt terrible noiſe, and fires which proceeded from the iſland that was newly formed. The whole maſs, however, of all this new-formed earth, uniting, encreaſed every day, both in height and breadth, and, by the force of its exploſions, caſt forth rocks to ſeven miles diſtance. This continued to bear the ſame dreadful appearances till the month of November in the ſame year; and it is at preſent a volcano which ſometimes renews its exploſions. It is about three miles in circumference; and more than from thirty-five to forty feet high."

It ſeems extraordinary, that about this place in particular, iſlands have appeared at different times, particularly that of Hiera, mentioned above, which has received conſiderable additions in ſucceeding ages. Juſtin * tells us, that at the time the Macedonians were at war with

* Juſtin, l. 30, cap. 4.

the Romans, a new iſland appeared between thoſe of Theramenes and Theraſia, by means of an earthquake. We are told, that this became half as big again about a thouſand years after; another iſland riſing up by its ſide, and joining to it, ſo as ſcarce at preſent to be diſtinguiſhed from the former.

A new iſland was formed, in the year 1720, near that of Tercera, near the continent of Africa, by the ſame cauſes. In the beginning of December, at night, there was a terrible earthquake at that place, and the top of a new iſland appeared, which caſt forth ſmoke in vaſt quantities. The pilot of a ſhip, who approached it, ſounded on one ſide of this iſland, and could not find ground at ſixty fathom. At the other ſide the ſea was totally tinged of a different colour, exhibiting a mixture of white, blue, and green; and was very ſhallow. This iſland, on its firſt appearance, was larger than it is at preſent; for it has, ſince that time, ſunk in ſuch a manner, as to be ſcarce above water.

A traveller, whom theſe appearances could not avoid affecting, ſpeaks of them in this manner: * "What can be more ſurpriſing than to ſee fire not only break out of the bowels of the earth, but alſo to make itſelf a paſſage through

* Phil. Tranſ. vol. v. p. 197.

the waters of the ſea! What can be more ex-traordinary or foreign to our common notions of things, than to ſee the bottom of the ſea riſe up into a mountain above the water, and be-come ſo firm an iſland as to be able to reſiſt the violence of the greateſt ſtorms! I know that ſub-terraneous fires, when pent in a narrow paſſage, are able to raiſe up a maſs of earth as large as an iſland. But that this ſhould be done in ſo regular and exact a manner that the water of the ſea ſhould not be able to penetrate and ex-tinguiſh thoſe fires; that, after having made ſo many paſſages, they ſhould retain force enough to raiſe the earth; and, in fine, after having been extinguiſhed, that the maſs of earth ſhould not fall down, or ſink again with its own weight, but ſtill remain in a manner ſuſpended over the great arch below! This is what to me ſeems more ſurpriſing than any thing that has been related of Mount Ætna, Veſuvius, or any other volcano."

Such are his ſentiments; however, there are few of theſe appearances any way more extraordinary than thoſe attending volcanoes and earthquakes in general. We are not more to be ſurpriſed that inflammable ſub-ſtances ſhould be found beneath the bottom of the ſea, than at ſimilar depths at land. Theſe

have all the force of fire giving expansion to air, and tending to raise the earth at the bottom of the sea, till it at length heaves above water. These marine volcanoes are not so frequent; for, if we may judge of the usual procedure of Nature, it must very often happen that, before the bottom of the sea is elevated above the surface, a chasm is opened in it, and then the water pressing in, extinguishes the volcano before it has time to produce its effects. This extinction, however, is not effected without very great resistance from the fire beneath. The water, upon dashing into the cavern, is very probably at first ejected back with great violence; and thus some of those amazing water-spouts are seen, which have so often astonished the mariner, and excited curiosity.——But of these in their place.

Besides the production of those islands by the action of fire, there are others, as was said, produced by rivers or seas carrying mud, earth, and such like substances, along with their currents; and at last depositing them in some particular place. At the mouths of most great rivers, there are to be seen banks, thus formed by the sand and mud carried down with the stream, which have rested at that place, where the force of the current is diminished by its junction with the sea. These banks, by slow

degrees, encreaſe at the bottom of the deep; the water in thoſe places, is at firſt found by mariners to grow more ſhallow; the bank ſoon heaves up above the ſurface; it is conſidered, for a while, as a tract of uſeleſs and barren ſand; but the ſeeds of ſome of the more hardy vegetables are driven thither by the wind, take root, and thus binding the ſandy ſurface, the whole ſpot is cloathed in time with a beautiful verdure. In this manner there are delightful and inhabited iſlands at the mouths of many rivers, particularly the Nile, the Po, the Miſſiſippi, the Ganges, and the Senegal. There has been, in the memory of man, a beautiful and large iſland formed in this manner, at the mouth of the river Nanquin, in China, made from depoſitions of mud at its opening: it is not leſs than ſixty miles long, and about twenty broad. La Loubere informs us *, in his voyage to Siam, that theſe ſand-banks encreaſe every day, at the mouths of all the great rivers in Aſia: and hence he aſſerts, that the navigation up theſe rivers becomes every day more difficult; and will, at one time or another, be totally obſtructed. The ſame may be remarked with regard to the Wolga, which has at preſent ſeventy openings into the Caſpian ſea; and of

* Lettres Curieuſes et Edifiantes, ſec. xi. p. 234.

the Danube, which has seven into the Euxine. We have had an inſtance of the formation of a new iſland, not very long ſince, at the mouth of the Humber, in England. "It is yet within the memory of man," ſays the relator *, "ſince it began to raiſe its head above the ocean. It began its appearance at low water, for the ſpace of a few hours; and was buried again till the next tide's retreat. Thus, ſucceſſively, it lived and died, until the year 1666, when it began to maintain its ground againſt the inſult of the waves; and then firſt invited the aid of human induſtry. A bank was thrown about its riſing grounds; and being thus defended from the incurſions of the ſea, it became firm and ſolid, and, in a ſhort time, afforded good paſturage for cattle. It is about nine miles in circumference, and is worth to the proprietor about eight hundred pounds a year." It would be endleſs to mention all the iſlands that have been thus formed, and the advantages that have been derived from them. However, it is frequently found, that new iſlands may often be conſidered as only turning the rivers from their former beds; ſo that, in proportion as land is gained at one part, it is loſt by the overflowing of ſome other.

* Phil. Tranſ. vol. iv. p. 251.

Little, therefore, is gained by ſuch acceſſions; nor is there much more by the new iſlands which are ſometimes formed from the ſpoils of the continent. Mariners aſſure us, that there are ſometimes whole plains unrooted from the main lands, by floods and tempeſts. Theſe, being carried out to ſea, with all their trees and animals upon them, are frequently ſeen floating in the ocean, and exhibiting a ſurpriſing appearance of rural tranquillity in the midſt of danger. The greateſt part, however, having the earth at their roots at length waſhed away, are diſperſed, and their animals drowned; but now and then ſome are found to brave the fury of the ocean, till being ſtuck either among rocks or ſands, they again take firm footing, and become permanent iſlands.

As different cauſes have thus concurred to produce new iſlands, ſo we have accounts of others that the ſame cauſes have contributed to deſtroy. We have already ſeen the power of earthquakes exerted in ſinking whole cities, and leaving lakes in their room. There have been iſlands, and regions alſo, that have ſhared the ſame fate; and have ſunk with their inhabitants, never more to be heard of. Thus Pauſanias * tells us of an iſland, called Chryſes, that was

* Pauſanias, l. 8. in Arcad. p. 509.

funk near Lemnos. Pliny mentions feveral; among others, the ifland Cea, for thirty miles, having been wafhed away, with feveral thoufands of its inhabitants. But of all the noted devaftations of this kind, the total fubmerfion of the ifland of Atalantis, as mentioned by Plato, has been moft the fubject of fpeculation. Mankind, in general, now confider the whole of his account as an ingenious fable; but when fables are grown famous by time and authority, they become an agreeable, if not a neceffary part of literary information.

" About nine thoufand years are paffed," fays Plato*, " fince the ifland of Atalantis was in being. The priefts of Egypt were well acquainted with it; and the firft heroes of Athens gained much glory in their wars with the inhabitants. This ifland was as large as Afia Minor and Syria united; and was fituated beyond the pillars of Hercules, in the Atlantic ocean. The beauty of the buildings, and the fertility of the foil, were far beyond any thing a modern imagination can conceive; gold and ivory were every where common; and the fruits of the earth offered themfelves without cultivation. The arts, and the courage of the inhabitants, were not inferior to the happinefs of their fitu-

† Plato in Critia.

ation; and they were frequently known to make conqueſts, and over-run the continent of Europe and Aſia. The imagination of the poetical philoſopher riots in the deſcription of the natural and acquired advantages, which they long enjoyed in this charming region. If, ſays he, we compare that country to our own, ours will appear a mere waſted ſkeleton, when oppoſed to it. Their mountains to the very tops were cloathed with fertility, and poured down rivers to enrich the plains below."

However, all theſe beauties and benefits were deſtroyed in one day by an earthquake ſinking the earth, and the ſea overwhelming it. At preſent, not the ſmalleſt veſtiges of ſuch an iſland are to be found; Plato remains as the only authority for its exiſtence; and philoſophers diſpute about its ſituation. It is not for me to enter into the controverſy, when there appears but little probability to ſupport the fact; and, indeed, it would be uſeleſs to run back nine thouſand years in ſearch of difficulties, as we are ſurrounded with objects that more cloſely affect us, and that demand admiration at our very doors. When I conſider, as Lactantius ſuggeſts, the various viciſſitudes of nature; lands ſwallowed by yawning earthquakes, or overwhelmed in the deep; rivers and lakes diſap-

pearing, or dried away; mountains levelled into plains; and plains ſwelling up into mountains; I cannot help regarding this earth as a place of very little ſtability: as a tranſient abode of ſtill more tranſitory beings.

CHAP. XII.

Of Mountains.

HAVING at laſt, in ſome meaſure, emerged from the deeps of the earth, we come to a ſcene of greater ſplendour; the contemplation of its external appearance. In this ſurvey, its mountains are the firſt objects that ſtrike the imagination, and excite our curioſity. There is not, perhaps, any thing in all nature that impreſſes an unaccuſtomed ſpectator with ſuch ideas of awful ſolemnity, as theſe immenſe piles of Nature's erecting, that ſeem to mock the minuteneſs of human magnificence.

In countries where there are nothing but plains, the ſmalleſt elevations are apt to excite wonder. In Holland, which is all a flat, they ſhew a little ridge of hills, near the ſea-ſide, which Boerhaave generally marked out to his pupils as being mountains of no ſmall con-

fideration. What would be the fenfations of fuch an auditory, could they at once be prefented with a view of the heights and precipices of the Alps, or the Andes! Even among us, in England, we have no adequate ideas of a mountain-profpect; our hills are generally floping from the plain, and cloathed to the very top with verdure; we can fcarce, therefore, lift our imaginations to thofe immenfe piles whofe tops peep up behind intervening clouds, fharp and precipitate, and reach to heights that human avarice or curiofity have never been able to afcend.

We, in this part of the world, are not, for that reafon, fo immediately interefted in the queftion which has fo long been agitated among philofophers, concerning what gave rife to thefe inequalities on the furface of the globe. In our own happy region, we generally fee no inequalities but fuch as contribute to ufe and beauty; and we, therefore, are amazed at a queftion enquiring how fuch neceffary inequalities came to be formed, and feeming to exprefs a wonder how the globe comes to be fo beautiful as we find it. But though with us there may be no great caufe for fuch a demand, yet in thofe places where mountains deform the face of Nature, where they pour down cataracts, or give fury

to tempefts, there feems to be good reafon for enquiry either into their caufes or their ufes. It has been, therefore, afked by many, in what manner mountains have come to be formed; or for what ufes they are defigned?

To fatisfy curiofity in thefe refpects, much reafoning has been employed, and very little knowledge propagated. With regard to the firft part of the demand, the manner in which mountains were formed, we have already feen the conjectures of different philofophers on that head. One fuppofing that they were formed from the earth's broken fhell, at the time of the deluge: another, that they exifted from the creation, and only acquired their deformities in procefs of time: a third, that they owed their original to earthquakes: and ftill a fourth, with much more plaufibility than the reft, afcribing them entirely to the fluctuations of the deep, which he fuppofes in the beginning to have covered the whole earth. Such as are pleafed with difquifitions of this kind, may confult Burnet, Whifton, Woodward, or Buffon. Nor would I be thought to decry any mental amufements, that at worft keep us innocently employed; but, for my own part, I cannot help wondering how the oppofite demand has never come to be made; and why

philoſophers have never aſked how we come to have plains? Plains are ſometimes more prejudicial to man than mountains. Upon plains, an inundation has greater power; the beams of the ſun are often collected there with ſuffocating fierceneſs; they are ſometimes found deſert for ſeveral hundred miles together, as in the country eaſt of the Caſpian ſea, although otherwiſe fruitful, merely becauſe there are no riſings nor depreſſions to form reſervoirs, or collect the ſmalleſt rivulet of water. The moſt rational anſwer, therefore, why either mountains or plains were formed, ſeems to be, that they were thus faſhioned by the hand of Wiſdom, in order that pain and pleaſure ſhould be ſo contiguous, as that morality might be exerciſed either in bearing the one, or communicating the other.

Indeed, the more I conſider this diſpute reſpecting the formation of mountains, the more I am ſtruck with the futility of the queſtion. There is neither a ſtrait line, nor an exact ſuperficies, in all nature. If we conſider a circle, even with mathematical preciſion, we ſhall find it formed of a number of ſmall right lines, joining at angles together. Theſe angles, therefore, may be conſidered in a circle as mountains are upon our globe; and to demand the reaſon

for the one being mountainous, or the other angular, is only to aſk why a circle is a circle, or a globe is a globe. In ſhort, if there be no ſurface without inequality in Nature, why ſhould we be ſurpriſed that the earth has ſuch? It has often been ſaid, that the inequalities of its ſurface are ſcarce diſtinguiſhable, if compared to its magnitude; and I think we have every reaſon to be content with the anſwer.

Some, however, have avoided the difficulty by urging the final cauſe. They alledge that mountains have been formed merely becauſe they are uſeful to man. This carries the enquirer but a part of the way; for no one can affirm that in all places they are uſeful. The contrary is known, by horrid experience, in thoſe valleys that are ſubject to their influence. However, as the utility of any part of our earthly habitation, is a very pleaſing and flattering ſpeculation to every philoſopher, it is not to be wondered that much has been ſaid to prove the uſefulneſs of theſe. For this purpoſe, many conjectures have been made that have received a degree of aſſent even beyond their evidence; for men were unwilling to become more miſerably wiſe.

It has been alledged, as one principal ad-

vantage that we derive from them, that they ferve, like hoops or ribs, to ftrengthen our earth, and to bind it together. In confequence of this theory, Kircher has given us a map of the earth, in this manner hooped with its mountains; which might have a much more folid foundation, did it entirely correfpond with truth.

Others have found a different ufe for them, efpecially when they run furrounding our globe; which is, that they ftop the vapours which are continually travelling from the equator to the poles; for thefe being urged by the heat of the fun, from the warm regions of the line, muft all be accumulated at the poles, if they were not ftopped in their way by thofe high ridges of mountains which crofs their direction. But an anfwer to this may be, that all the great mountains in America lie lengthwife, and therefore do not crofs their direction.

But to leave thefe remote advantages, others affert, that not only the animal but vegetable part of the creation would perifh for want of convenient humidity, were it not for their friendly affiftance. Their fummits are, by thefe, fuppofed to arreft, as it were, the vapours which float in the regions of the air. Their large inflexions, and channels, are confidered as

ſo many baſons prepared for the reception of thoſe thick vapours, and impetuous rains, which deſcend into them. The huge caverns beneath are ſo many magazines or conſervatories of water for the peculiar ſervice of man: and thoſe orifices by which the water is diſcharged upon the plain, are ſo ſituated as to enrich and render them fruitful, inſtead of returning through ſubterraneous channels to the ſea, after the performance of a tedious and fruitleſs circulation *.

However this be, certain it is that almoſt all our great rivers find their ſource among mountains; and, in general, the more extenſive the mountain, the greater the river: thus the river Amazons, the greateſt in the world, has its ſource among the Andes, which are the higheſt mountains on the globe; the river Niger travels a long courſe of ſeveral hundred miles from the mountains of the Moon, the higheſt in all Africa; and the Danube and the Rhine proceed from the Alps, which are probably the higheſt mountains of Europe.

It need ſcarce be ſaid that, with reſpect to height, there are many ſizes of mountains, from the gently riſing upland, to the tall craggy

* Nature Diſplayed, vol. iii. p. 88.

precipice. The appearance is in general different in those of different magnitudes. The first are cloathed with verdure to the very tops, and only seem to ascend to improve our prospects, or supply us with a purer air: but the lofty mountains of the other class have a very different aspect. At a distance their tops are seen, in wavy ridges, of the very colour of the clouds, and only to be distinguished from them by their figure, which, as I have said, resemble the billows of the sea *. As we approach, the mountain assumes a deeper colour; it gathers upon the sky, and seems to hide half the horizon behind it. Its summits also are become more distinct, and appear with a broken and perpendicular line. What at first seemed a single hill, is now found to be a chain of continued mountains, whose tops running along in ridges, are embosomed in each other; so that the curvatures of one are fitted to the prominences of the opposite side, and form a winding valley between, often of several miles in extent; and all the way continuing nearly of the same breadth.

Nothing can be finer, or more exact, than Mr. Pope's description of a traveller straining up the Alps. Every mountain he comes to he thinks will be the last; he finds, how-

* Lettres Philosophiques sur la Formation, &c. p. 196.

ever, an unexpected hill riſe before him; and that being ſcaled, he finds the higheſt ſummit almoſt at as great a diſtance as before. Upon quitting the plain, he might have left a green and a fertile ſoil, and a climate warm and pleaſing. As he aſcends, the ground aſſumes a more ruſſet colour; the graſs becomes more moſſy, and the weather more moderate. Still as he aſcends, the weather becomes more cold, and the earth more barren. In this dreary paſſage, he is often entertained with a little valley of ſurpriſing verdure, cauſed by the reflected heat of the ſun collected into a narrow ſpot on the ſurrounding heights. But it much more frequently happens that he ſees only frightful precipices beneath, and lakes of amazing depths; from whence rivers are formed, and fountains derive their original. On thoſe places next the higheſt ſummits, vegetation is ſcarcely carried on; here and there a few plants of the moſt hardy kind appear. The air is intolerably cold; either continually refrigerated with froſts, or diſturbed with tempeſts. All the ground here wears an eternal covering of ice, and ſnows that ſeem conſtantly accumulating. Upon emerging from this war of the elements, he aſcends into a purer and a ſerener region, where vegetation is entirely

ceased; where the precipices, composed entirely of rocks, rise perpendicularly above him; while he views beneath him all the combat of the elements; clouds at his feet; and thunders darting upward from their bosoms below*. A thousand meteors, which are never seen on the plain, present themselves. Circular rainbows†; mock suns; the shadow of the mountain projected upon the body of the air‡; and the traveller's own image, reflected as in a looking-glass, upon the opposite cloud ‖.

Such are, in general, the wonders that present themselves to a traveller in his journey either over the Alps or the Andes. But we must not suppose that this picture exhibits either a constant or an invariable likeness of those stupendous heights. Indeed, nothing can be more capricious or irregular than the forms of many of them. The tops of some run in ridges for a considerable length, without interruption; in others, the line seems indented by great vallies to an amazing depth. Sometimes a solitary and a single mountain rises from the bosom of the plain; and sometimes extensive plains, and even provinces, as those of Savoy and Quito, are found embosomed near the tops of mountains. In general,

* Ulloa, vol. i. † Ibid. ‡ Phil. Transf. vol. v. p. 152. ‖ Ulloa, vol. i.

however, those countries that are most mountainous, are the most barren and uninhabitable.

If we compare the heights of mountains with each other, we shall find that the greatest and highest are found under the Line *. It is thought by some, that the rapidity of the earth's motion in these parts, together with the greatness of the tides there, may have thrown up those stupendous masses of earth. But, be the cause as it may, it is a remarkable fact, that the inequalities of the earth's surface are greatest there. Near the Poles, the earth, indeed, is craggy and uneven enough; but the heights of the mountains there are very inconsiderable. On the contrary, at the Equator, where Nature seems to sport in the amazing size of all her productions, the plains are extensive; and the mountains remarkably lofty. Some of them are known to rise three miles perpendicular above the bed of the ocean.

To enumerate the most remarkable of these, according to their size, we shall begin with the Andes, of which we have an excellent description by Ulloa, who went thither by command of the king of Spain, in company with the French Academicians, to measure a degree of the meridian. His journey up these

* Buffon, passim.

mountains is too curious not to give an extract from.

After many incommodious days ſailing up the river Guayaquil, he arrived at Caracol, a town ſituated at the foot of the Andes. Nothing could exceed the inconveniencies which he experienced in this voyage, from the flies and moſchitoes (an animal reſembling our gnat). "We were the whole day," ſays he, "in continual motion to keep them off; but at night our torments were exceſſive. Our gloves, indeed, were ſome defence to our hands; but our faces were entirely expoſed; nor were our cloaths a ſufficient defence for the reſt of our bodies; for their ſtings penetrating through the cloth, cauſed a very painful and fiery itching. One night, in coming to an anchor near a large and handſome houſe that was uninhabited, we had no ſooner ſeated ourſelves in it, than we were attacked on all ſides by ſwarms of moſchitoes, ſo that it was impoſſible to have one moment's quiet. Thoſe who had covered themſelves with cloaths made for this purpoſe, found not the ſmalleſt defence; wherefore, hoping to find ſome relief in the open fields, they ventured out, though in danger of ſuffering in a more terrible manner from the ſerpents. But both places were equally obnoxious. On quitting

this inhospitable retreat, we the next night took up our quarters in a houſe that was inhabited; the hoſt of which being informed of the terrible manner we had paſſed the night before, he gravely told us, that the houſe we ſo greatly complained of, had been forſaken on account of its being the purgatory of a ſoul. But we had more reaſon to believe that it was quitted on account of its being the purgatory of the body. After having journeyed for upwards of three days, through boggy roads, in which the mules at every ſtep ſunk up to their bellies, we began at length to perceive an alteration in the climate; and having been long accuſtomed to heat, we now began to feel it grown ſenſibly colder.

"It is remarkable, that at Tariguagua we often ſee inſtances of the effects of two oppoſite temperatures, in two perſons happening to meet; one of them leaving the plains below, and the other deſcending from the mountain. The former thinks the cold ſo ſevere, that he wraps himſelf up in all the garments he can procure; while the latter, finds the heat ſo great, that he is ſcarce able to bear any cloaths whatſoever. The one thinks the water ſo cold, that he avoids being ſprinkled by it; the other is ſo delighted with its warmth, that he uſes it

as a bath. Nor is the cafe very different in the fame perfon, who experiences the fame diverfity of fenfation upon his journey up, and upon his return. This difference only proceeds from the change naturally felt at leaving a climate to which one has been accuftomed, and coming into another of an oppofite temperature.

" The ruggednefs of the road from Tariguagua, leading up the mountain, is not eafily defcribed. In fome parts, the declivity is fo great, that the mules can fcarce keep their footing; and in others, the acclivity is equally difficult. The trouble of having people going before to mend the road, the pains arifing from the many falls and bruifes, and the being conftantly wet to the fkin, might be fupported, were not thefe inconveniencies augmented by the fight of fuch frightful precipices, and deep abyffes, as muft fill the mind with ceafelefs terror. There are fome places where the road is fo fteep, and yet fo narrow, that the mules are obliged to flide down, without making any ufe of their feet whatfoever. On one fide of the rider, in this fituation, rifes an eminence of feveral hundred yards; and on the other, an abyfs of equal depth; fo that if he in the leaft checks his mule, fo as to deftroy the equilibrium, they both muft unavoidably perifh.

"After having travelled about nine days in this manner, ſlowly winding along the ſide of the mountain, we began to find the whole country covered with an hoar froſt; and an hut in which we lay had ice on it. Having eſcaped many perils, we at length, after a journey of fifteen days, arrived upon the plain, on the extremity of which ſtands the city of Quito, the capital of one of the moſt charming regions upon earth. Here, in the center of the torrid zone, the heat is not only very tolerable, but in ſome places the cold alſo is painful. Here they enjoy all the temperature and advantages of perpetual ſpring; their fields being always covered with verdure, and enamelled with flowers of the moſt lively colours. However, although this beautiful region be higher than any other country in the world, and although it took up ſo many days of painful journey in the aſcent, it is ſtill overlooked by tremendous mountains; their ſides covered with ſnow, and yet flaming with volcanoes at the top. Theſe ſeem piled one upon the other, and riſe to a moſt aſtoniſhing height, with great coldneſs. However, at a determined point above the ſurface of the ſea, the congelation is found at the ſame height in all the mountains. Thoſe parts which are not ſubject to a continual froſt,

have here and there growing upon them a rufh, refembling the genifta, but much more foft and flexible. Towards the extremity of the part where the rufh grows, and the cold begins to encreafe, is found a vegetable, with a round bulbous head, which, when dried, becomes of amazing elafticity. Higher up the earth is entirely bare of vegetation, and feems covered with eternal fnow. The moft remarkable mountains are, that of Cotopaxi, (already defcribed as a volcano) Chimborazo, and Pichincha. Cotopaxi is more than three geographical miles above the furface of the fea: the reft are not much inferior. On the top of the latter was my ftation for meafuring a degree of the meridian; where I fuffered particular hardfhips, from the intenfenefs of the cold, and the violence of the ftorms. The fky around was, in general, involved in thick fogs, which, when they cleared away, and the clouds, by their gravity, moved nearer to the furface of the earth, they appeared furrounding the foot of the mountain, at a vaft diftance below, like a fea, emcompaffing an ifland in the midft of it. When this happened, the horrid noifes of tempefts were heard from beneath, then difcharging themfelves on Quito, and the neighbouring

country. I ſaw the lightenings iſſue from the clouds, and heard the thunders roll far beneath me. All this time, while the tempeſt was raging below, the mountain top, where I was placed, enjoyed a delightful ſerenity; the wind was abated; the ſky clear; and the enlivening rays of the ſun moderated the ſeverity of the cold. However, this was of no very long duration, for the wind returned with all its violence, and with ſuch velocity as to dazzle the ſight; whilſt my fears were encreaſed by the dreadful concuſſions of the precipice, and the fall of enormous rocks; the only ſounds that were heard in this frightful ſituation."

Such is the animated picture of theſe mountains, as given us by this ingenious Spaniard: and I believe the reader will wiſh that I had made the quotation ſtill longer. A paſſage over the Alps, or a journey acroſs the Pyrenees, appear petty trips or excurſions, in the compariſon; and yet theſe are the moſt lofty mountains we know of in Europe.

If we compare the Alps with the mountains already deſcribed, we ſhall find them but little more than one half of the height of the former. The Andes, upon being meaſured by the barometer, are found above three thouſand one

hundred and thirty-fix toifes or fathoms above the furface of the fea *. Whereas the higheft point of the Alps is not above fixteen hundred. The one, in other words, is above three miles high; the other, about a mile and a half. The higheft mountains in Afia are, Mount Taurus, Mount Immaus, Mount Caucafus, and the mountains of Japan.—Of thefe, none equals the Andes in height; although Mount Caucafus, which is the higheft of them, makes very near approaches. Father Verbieft tells of a mountain in China, which he meafured, and found a mile and a half high †. In Africa, the mountains of the Moon, famous for giving fource to the Niger, and the Nile, are rather more noted than known. Of the Pike of Teneriffe, one of the Canary Iflands that lie off this coaft, we have more certain information. In the year 1727, it was vifited by a company of Englifh merchants, who travelled up to the top, where they obferved its height, and the volcano on its very fummit ‡. They found it an heap of mountains, the higheft of which rifes over the reft like a fugar-loaf, and gives a name to the whole mafs. It is computed to be a mile and an half perpendicular from the furface of the

* Ulloa, vol. i. p. 442. † Verbieft, à la Chine.
‡ Phil. Tranf. vol. v.

sea. Kircher gives us an eftimate of the heights of moft of the other great mountains in the world; but as he has taken his calculations, in general, from the ancients, or from modern travellers, who had not the art of meafuring them, they are quite incredible. The art of taking the heights of places by the barometer, is a new, and an ingenious invention. As the air grows lighter as we afcend, the fluid in the tube rifes in due proportion: thus the inftrument being properly marked, gives the height with a tolerable degree of exactnefs; at leaft enough to fatisfy curiofity.

Few of our great mountains have been eftimated in this manner; travellers having, perhaps, been deterred, by a fuppofed impoffibility of breathing at the top. However, it has been invariably found, that the air in the higheft that our modern travellers have afcended, is not at all too fine for refpiration. At the top of the Pike of Teneriffe, there was found no other inconvenience from the air, except its coldnefs; at the top of the Andes there was no difficulty of breathing perceived. The accounts, therefore, of thofe who have afferted that they were unable to breathe, although at much lefs heights, are greatly to be fufpected. In fact, it is very natural for mankind to paint thofe obftacles as

insurmountable, which they themselves have not had the fortitude or perseverance to surmount.

The difficulty and danger of ascending to the tops of mountains, proceeds from other causes, not the thinness of the air. For instance, some of the summits of the Alps have never yet been visited by man; but the reason is, that they rise with such a rugged and precipitate ascent, that they are utterly inaccessible. In some places they appear like a great wall of six or seven hundred feet high; in others, there stick out enormous rocks, that hang upon the brow of the steep, and every moment threaten destruction to the traveller below.

In this manner almost all the tops of the highest mountains are bare and pointed. And this naturally proceeds from their being so continually assaulted by thunders and tempests. All the earthy substances with which they might have been once covered, have for ages been washed away from their summits; and nothing is left remaining, but immense rocks, which no tempest has hitherto been able to destroy.

Nevertheless, time is every day, and every hour, making depredations; and huge fragments are seen tumbling down the precipice, either loosened from the summit by frost or

rains, or ſtruck down by lightening. Nothing can exhibit a more terrible picture than one of theſe enormous rocks, commonly larger than an houſe, falling from its height, with a noiſe louder than thunder, and rolling down the ſide of the mountain. Doctor Plot tells us of one in particular, which being looſened from its bed, tumbled down the precipice, and was partly ſhattered into a thouſand pieces. Notwithſtanding, one of the largeſt fragments of the ſame, ſtill preſerving its motion, travelled over the plain below, croſſed a rivulet in the midſt, and at laſt ſtopped on the other ſide of the bank! Theſe fragments, as was ſaid, are often ſtruck off by lightening, and ſometimes undermined by rains; but the moſt uſual manner in which they are diſunited from the mountain, is by froſt: the rains inſinuating between the interſtices of the mountain, continue there until there comes a froſt, and then, when converted into ice, the water ſwells with an irreſiſtible force, and produces the ſame effect as gun-powder, ſplitting the moſt ſolid rocks, and thus ſhattering the ſummits of the mountain.

But not rocks alone, but whole mountains are, by various cauſes, diſunited from each other. We ſee, in many parts of the Alps,

amazing clefts, the ſides of which ſo exactly correſpond with the oppoſite, that no doubt can be made of their having been once joined together. At Cajeta *, in Italy, a mountain was ſplit in this manner by an earthquake; and there is a paſſage opened through it, that appears as if elaborately done by the induſtry of man. In the Andes theſe breaches are frequently ſeen. That at Thermopyle, in Greece, has been long famous. The mountain of the Troglodytes, in Arabia, has thus a paſſage through it: and that in Savoy, which Nature began, and which Victor Amadeus completed, is an inſtance of the ſame kind.

We have accounts of ſome of theſe diſruptions, immediately after their happening. "In the month of June †, in the year 1714, a part of the mountain of Diableret, in the diſtrict of Valais, in France, ſuddenly fell down, between two and three o'clock in the afternoon, the weather being very calm and ſerene. It was of a conical figure, and deſtroyed fifty-five cottages in the fall. Fifteen perſons, together with about an hundred beaſts, were alſo cruſhed beneath its ruins, which covered an extent of a good league ſquare. The duſt it occaſioned, inſtantly covered all the neighbour-

* Buffon, vol. ii. p. 364.

† Hiſt. de l' Académie des Sciences, p. 4. an. 1715.

hood in darkneſs. The heaps of rubbiſh were more than three hundred feet high. They ſtopped the current of a river that ran along the plain, which is now formed into ſeveral new and deep lakes. There appeared, through the whole of this rubbiſh, none of thoſe ſubſtances that ſeemed to indicate that this diſruption had been made by means of ſubterraneous fires. Moſt probably, the baſe of this rocky mountain was rotted and decayed; and thus fell without any extraneous violence." In the ſame manner, in the year 1618, the town of Pleurs, in France, was buried beneath a rocky mountain, at the foot of which it was ſituated.

Theſe accidents, and many more that might be enumerated of the ſame kind, have been produced by various cauſes: by earthquakes, as in the mountain at Cajeta; or by being decayed at the bottom, as at Diableret. But the moſt general way is, by the foundation of one part of the mountain being hollowed by waters, and, thus wanting a ſupport, breaking from the other. Thus it generally has been found in the great chaſms in the Alps; and thus it almoſt always is known in thoſe diſruptions of hills, which are known by the name of land-ſlips. Theſe are nothing more than the ſlidings down of an higher piece of ground, diſrooted from its

ſituation by ſubterraneous inundations, and ſettling itſelf upon the plain below.

There is not an appearance in all nature that ſo much aſtoniſhed our anceſtors, as theſe land-ſlips. In fact, to behold a large upland, with its houſes, its corn, and cattle, at once looſened from its place, and floating, as it were, upon the ſubjacent water; to behold it quitting its ancient ſituation, and travelling forward like a ſhip, in queſt of new adventures; this is certainly one of the moſt extraordinary appearances that can be imagined; and to a people, ignorant of the powers of Nature, might well be conſidered as a prodigy. Accordingly, we find all our old hiſtorians mentioning it as an omen of approaching calamities. In this more enlightened age, however, its cauſe is very well known; and, inſtead of exciting ominous apprehenſions in the populace, it only gives riſe to ſome very ridiculous law-ſuits among them, about whoſe the property ſhall be; whether the land which has thus ſlipt, ſhall belong to the original poſſeſſor, or to him upon whoſe grounds it has encroached and ſettled. What has been the determination of the judges, is not ſo well known; but the circumſtances of the ſlips have been minutely and exactly deſcribed.

In the lands of Slatberg *, in the kingdom of Iceland, there ſtood a declivity, gradually aſcending for near half a mile. In the year 1713, and on the 10th of March, the inhabitants perceived a crack on its ſide, ſomewhat like a furrow made with a plough, which they imputed to the effects of lightening, as there had been thunder the night before. However, on the evening of the ſame day, they were ſurpriſed to hear an hideous confuſed noiſe iſſuing all round from the ſide of the hill; and their curioſity being raiſed, they reſorted to the place. There, to their amazement, they found the earth, for near five acres, all in gentle motion, and ſliding down the hill upon the ſubjacent plain. This motion continued the remaining part of the day, and the whole night; nor did the noiſe ceaſe during the whole time; proceeding, probably, from the attrition of the ground beneath. The day following, however, this ſtrange journey down the hill ceaſed entirely; and above an acre of the meadow below was found covered with what before compoſed a part of the declivity.

However, theſe ſlips, when a whole mountain's ſide ſeems to deſcend, happen but very rarely. There are ſome of another kind, how-

* Phil. Tranſ. vol. iv. p. 250.

ever, much more common; and, as they are always ſudden, much more dangerous. Theſe are ſnow-ſlips, well known, and greatly dreaded by travellers. It often happens, that when ſnow has long been accumulated on the tops and on the ſides of mountains, it is borne down the precipice, either by means of tempeſts, or its own melting. At firſt, when looſened, the volume in motion is but ſmall, but gathers as it continues to roll; and, by the time it has reached the habitable parts of the mountain, is generally grown of enormous bulk. Where-ever it rolls it levels all things in its way, or buries them in unavoidable deſtruction. Inſtead of rolling, it ſometimes is found to ſlide along from the top; yet even thus it is generally as fatal as before. Nevertheleſs, we have had an inſtance, a few years ago, of a ſmall family in Germany, that lived for above a fortnight beneath one of theſe ſnow-ſlips. Although they were buried, during that whole time, in utter darkneſs, and under a bed of ſome hundred feet deep, yet they were luckily taken out alive; the weight of the ſnow being ſupported by a beam that kept up the roof; and nouriſhment being ſupplied them by the milk of an aſs, if I remember right, that was buried under the ſame ruin.

But it is not the parts, alone, that are thus found to fubfide, whole mountains have been known totally to difappear. Pliny * tells us, that in his own time, the lofty mountain of Cybotus, together with the city of Eurites, were fwallowed by an earthquake. The fame fate, he fays, attended Phlegium, one of the higheft mountains in Æthiopia; which, after one night's concuffion, was never feen more. In more modern times, a very noted mountain in the Molucca iflands, known by the name of the Peak, and remarkable for being feen at a very great diftance from fea, was fwallowed by an earthquake; and nothing but a lake was left in the place where it ftood. Thus, while ftorms and tempefts are levelled againft mountains above, earthquakes and waters are undermining them below. All our hiftories talk of their deftruction; and very few new ones (if we except Mount Cenere, and one or two fuch heaps of cinders) are produced. If mountains, therefore, were of fuch great utility as fome philofophers make them to mankind, it would be a very melancholy confideration that fuch benefits were diminifhing every day. But the truth is, the valleys are fertilized by that earth which is wafhed from their fides;

* Plin. l. 2. cap. 93.

and the plains become richer, in proportion as the mountains decay.

CHAP. XIII.

Of Water.

IN contemplating nature, we ſhall often find the ſame ſubſtances poſſeſſed of contrary qualities, and producing oppoſite effects. Air, which liquifies one ſubſtance, dries up another. That fire which is ſeen to burn up the deſart, is often found, in other places, to aſſiſt the luxuriance of vegetation; and water, which, next to fire, is the moſt fluid ſubſtance upon earth, nevertheleſs, gives all other bodies their firmneſs and durability; ſo that every element ſeems to be a powerful ſervant, capable either of good or ill, and only awaiting external direction, to become the friend or the enemy of mankind. Theſe oppoſite qualities, in this ſubſtance in particular, have not failed to excite the admiration and enquiry of the curious.

That water is the moſt fluid penetrating body, next to fire, and the moſt difficult to confine, is inconteſtibly proved by a variety of experiments. A veſſel through which water cannot paſs, may be ſaid to retain any thing. It may

be objected, indeed, that syrups, oils, and honey, leak through some vessels that water cannot pass through; but this is far from being the result of the greater tenuity and fineness of their parts; it is owing to the rosin wherewith the wood of such vessels abounds, which oils and syrups have a power of dissolving; so that these fluids, instead of finding their way, may more properly be said to eat their way through the vessels that contain them. However, water will at last find its way even through these; for it is known to escape through vessels of every substance, glass only excepted. Other bodies may be found to make their way out more readily indeed; as air, when it finds a vent, will escape at once; and quicksilver, because of its weight, quickly penetrates through whatever chinky vessel confines it: but water, though it operates more slowly, yet always finds a more certain issue. As, for instance, it is well known that air will not pass through leather; which water will very readily penetrate. Air also may be retained in a bladder; but water will quickly ooze through. And those who drive this to the greatest degree of precision, pretend to say, that it will pass through pores ten times smaller than air can do. Be this as it may, we are very certain that its parts are so small that they have

been actually driven through the pores of gold. This has been proved by the famous Florentine experiment, in which a quantity of water was ſhut up in an hollow ball of gold, and then preſſed with an huge force by ſcrews, during which the fluid was ſeen to ooze through the pores of the metal, and to ſtand, like a dew, upon its ſurface.

As water is thus penetrating, and its parts thus minute, it may eaſily be ſuppoſed that they enter into the compoſition of all bodies, vegetable, animal, and foſſil. This every chemiſt's experience convinces him of; and the mixture is the more obvious, as it can always be ſeparated, by a gentle heat, from thoſe ſubſtances with which it had been united. Fire, as was ſaid, will penetrate where water cannot paſs; but then it is not ſo eaſily to be ſeparated. But there is ſcarce any ſubſtance from which its water cannot be divorced. The parings or filings of lead, tin, and antimony, by diſtillation, yield water plentifully: the hardeſt ſtones, ſea-ſalt, nitre, vitriol, and ſulphur, are found to conſiſt chiefly of water; into which they reſolve by force of fire. "All birds, beaſts, and fiſhes," ſays Newton, "inſects, trees, and vegetables, with their parts, grow from water; and, by putrefaction, return to water again." In ſhort,

almoſt every ſubſtance that we ſee, owes its texture and firmneſs to the parts of water that mix with its earth; and, deprived of this fluid, becomes a maſs of ſhapeleſs duſt and aſhes.

From hence we ſee, as was above hinted, that this moſt fluid body, when mixed with others, gives them conſiſtence and form. Water, by being mixed with earth or aſhes, and formed into a veſſel, when baked before the fire, becomes a copel, remarkable for this, that it will bear the utmoſt force of the hotteſt furnace that art can contrive. So the Chineſe earth, of which porcelane is made, is nothing more than an artificial compoſition of earth and water united by heat; and which a greater degree of heat could eaſily ſeparate. Thus we ſee a body, extremely fluid of itſelf, in ſome meaſure aſſuming a new nature, by being united with others; we ſee a body, whoſe fluid and diſſolving qualities are ſo obvious, giving conſiſtence and hardneſs to all the ſubſtances of the earth.

From conſiderations of this kind, Thales, and many of the ancient philoſophers, held that all things were made of water. In order to confirm this opinion, Helmont made an experiment, by diveſting a quantity of earth of all its oils and ſalts, and then putting this earth,

ſo prepared, into an earthen pot, which nothing but rain-water could enter, and planting a willow therein; this vegetable, ſo planted, grew up to a conſiderable height and bulk, merely from the accidental aſperſion of rain-water; while the earth in which it was planted received no ſenſible diminution. From this experiment, he concluded, that water was the only nouriſhment of the vegetable tribe; and that vegetables, being the nouriſhment of animals, all organized ſubſtances, therefore, owed their ſupport and being only to water. But this has been ſaid by Woodward to be a miſtake: for he ſhews, that water being impregnated with earthy particles, is only the conveyer of ſuch ſubſtances into the pores of vegetables, rather than an encreaſer of them, by its own bulk: and likewiſe, that water is ever found to afford ſo much leſs nouriſhment, in proportion as it is purified by diſtillation. A plant in diſtilled water will not grow ſo faſt as in water not diſtilled: and if the ſame be diſtilled three or four times over, the plant will ſcarce grow at all, or receive any nouriſhment from it. So that water, as ſuch, does not ſeem the proper nouriſhment of vegetables, but only the vehicle thereof, which contains the nutritious particles, and carries them through all parts of the plant. Water,

in its pure ſtate, may ſuffice to extend or ſwell the parts of a plant, but affords vegetable matter in a moderate proportion.

However this be, it is agreed on all ſides, that water, ſuch as we find it, is far from being a pure ſimple ſubſtance. The moſt genuine, we know, is mixed with exhalations and diſſolutions of various kinds; and no expedient that has been hitherto diſcovered, is capable of purifying it entirely. If we filter and diſtil it a thouſand times, according to Boerhaave, it will ſtill depoſe a ſediment: and by repeating the proceſs, we may evaporate it entirely away, but can never totally remove its impurities. Some, however, aſſert, that water, properly diſtilled, will have no ſediment*; and that the little white ſpeck which is found at the bottom of the ſtill, is a ſubſtance that enters from without. Kircher uſed to ſhew, in his Muſæum, a phial of water, that had been kept for fifty years, hermetically ſealed †; during which time it depoſed no ſediment, but continued as tranſ-

* Hill's Hiſtory of Foſſils.

† Hermetically ſealing a glaſs veſſel, means no more than heating the mouth of the phial red hot; and thus when the glaſs is become pliant, ſqueezing the mouth together with a pair of pincers, and then twiſting it ſix or ſeven times round, which effectually cloſes it up.

parent as when firſt it was put in. How far, therefore, it may be brought to a ſtate of purity by diſtillation, is unknown; but we very well know, that all ſuch water as we every where ſee, is a bed in which plants, minerals, and animals, are all found confuſedly floating together.

Rain-water, which is a fluid of Nature's own diſtilling, and which has been raiſed ſo high by evaporation, is, nevertheleſs, a very mixed and impure ſubſtance. Exhalations of all kinds, whether ſalts, ſulphurs, or metals, make a part of its ſubſtance, and tend to encreaſe its weight. It we gather the water that falls, after a thunder clap, in a ſultry ſummer's day, and let it ſettle, we ſhall find a real ſalt ſticking at the bottom. In winter, however, its impure mixtures are fewer, but ſtill may be ſeparated by diſtillation. As to that which is generally caught pouring from the tops of houſes, it is particularly foul, being impregnated with the ſmoak of the chimnies, the vapour of the ſlates or tiles, and with other impurities that birds and animals may have depoſited there. Beſides, though it ſhould be ſuppoſed free from all theſe, it is mixed with a quantity of air, which, after being kept for ſome time, will be ſeen to ſeparate.

Spring-water is next in point of purity. This, according to Doctor Halley, is collected from the air itself; which being sated with water, and coming to be condensed by the evening's cold, is driven against the tops of the mountains, where being condensed, and collected, it trickles down by the sides, into the cavities of the earth; and running for a while underground, bubbles up in fountains upon the plain. This having made but a short circulation, has generally had no long time to dissolve or imbibe any foreign substances by the way.

River-water is generally more foul than the former. Wherever the stream flows, it receives a tincture from its channel. Plants, minerals, and animals, all contribute to add to its impurities: so that such as live at the mouths of great rivers, are generally subject to all those disorders which contaminated and unwholsome waters are known to produce. Of all the river-water in the world, that of the Indus, and the Thames, are said to be most light and wholesome.

The most impure fresh water that we know, is that of stagnating pools and lakes, which, in summer, may be more properly considered as a jelly of floating insects, than a collection of

water. In this, millions of little reptiles, undiſturbed by any current, which might cruſh their frames to pieces, breed and engender. The whole teems with ſhapeleſs life, and only grows more fruitful by encreaſing putrefaction.

Of the purity of all theſe waters, the lightneſs, and not the tranſparency, ought to be the teſt. Water may be extremely clear and beautiful to the eye, and yet very much impregnated with mineral particles. In fact, ſea-water is the moſt tranſparent of any, and yet is well known to contain a large mixture of ſalt and bitumen. On the contrary, thoſe waters which are lighteſt, have the feweſt diſſolutions floating in them; and may, therefore, be the moſt uſeful for all the purpoſes of life. But, after all, though much has been ſaid upon this ſubject; and although waters have been weighed with great aſſiduity, to determine their degree of ſalubrity; yet neither this, nor their curdling with ſoap, nor any other philoſophical ſtandard whatſoever, will anſwer the purpoſes of true information. Experience alone ought to determine the uſeful, or noxious qualities, of every ſpring; and experience aſſures us, that different kinds of water are adapted to different conſtitutions. An inconteſtible proof of this, are the many medicinal ſprings throughout the

world, whoſe peculiar benefits are known to the natives of their reſpective countries. Theſe are of various kinds, according to the different minerals with which they are impregnated; hot, ſaline, ſulphureous, bituminous, and oily. But the account of theſe will come moſt properly under that of the ſeveral minerals by which they are produced.

After all, therefore, we muſt be contented with an impure mixture for our daily beverage: and yet, perhaps, this very mixture may often be more ſerviceable to our health than that of a purer kind. We know that it is ſo with regard to vegetables: and why not, alſo, in general, to man? Be this as it will, if we are deſirous of having water in its greateſt purity, we are ordered, by the curious in this particular, to diſtil it from ſnow, gathered upon the tops of the higheſt mountains, and to take none but the outer and ſuperficial part thereof. This we muſt be ſatisfied to call pure water; but even this is far ſhort of the pure unmixed philoſophical element; which, in reality, is no where to be found.

As water is thus mixed with foreign matter, and often the repoſitory of minute animals, or vegetable ſeeds, we need not be ſurpriſed that, when carried to ſea, it is always found to pu-

trefy. But we muſt not ſuppoſe that it is the element itſelf, which thus grows putrid, and offenſive, but the ſubſtances with which it is impregnated. It is true, the utmoſt precautions are taken to deſtroy all vegetable and animal ſubſtances that may have previouſly been lodged in it, by boiling: but, notwithſtanding this, there are ſome that will ſtill ſurvive the operation; and others, that find their way during the time of its ſtowage. Seamen, therefore, aſſure us, that their water is generally found to putrefy twice, at leaſt, and ſometimes three times, in a long voyage. In about a month after it has been at ſea, when the bung is taken out of the caſk, it ſends up a noiſome and dangerous vapour, which would take fire upon the application of a candle *. The whole body of the water then is found replete with little worm-like inſects, that float, with great briſkneſs, through all its parts. Theſe generally live for about a couple of days; and then dying, by depoſiting their ſpoils, for a while encreaſe the putrefaction. After a time, the heavier parts of theſe ſinking to the bottom, the lighter float, in a ſcum, at the top; and this is what the mariners call, the water's purging itſelf. There are ſtill, however, another

* Phil. Tranſ. vol. v. part ii. p. 71.

race of insects, which are bred, very probably, from the spoils of the former; and produce, after some time, similar appearances: these dying, the water is then thought to change no more. However, it very often happens, especially in hot climates, that nothing can drive these nauseous insects from the ship's store of water. They often encrease to a very disagreeable and frightful size, so as to deter the mariner, though parching with thirst, from tasting that cup which they have contaminated.

This water, as thus described, therefore, is a very different fluid from that simple elementary substance upon which philosophical theories have been founded; and concerning the nature of which there have been so many disputes. Elementary water is no way compounded; but is without taste, smell, or colour; and incapable of being discerned by any of the senses, except the touch. This is the famous dissolvent of the chemists, into which, as they have boasted, they can reduce all bodies; and which makes up all other substances, only by putting on a different disguise. In some forms, it is fluid, transparent, and evasive of the touch; in others, hard, firm, and elastic. In some, it is stiffened by cold; in others, dissolved by fire. According to them, it only assumes external shapes

from accidental caufes; but the mountain is as much a body of water as the cake of ice that melts on its brow; and even the philofopher himfelf is compofed of the fame materials with the cloud or meteor which he contemplates.

Speculation feldom refts when it begins. Others, difallowing the univerfality of this fubftance, will not allow that in a ftate of nature there is any fuch thing as water at all. What affumes the appearance, fay they, is nothing more than melted ice. Ice is the real element of Nature's making; and when found in a ftate of fluidity, it is then in a ftate of violence. All fubftances are naturally hard; but fome more readily melt with heat than others. It requires a great heat to melt iron; a fmaller heat will melt copper: filver, gold, tin, and lead, melt with fmaller ftill: ice, which is a body like the reft, melts with a very moderate warmth; and quickfilver melts with the fmalleft warmth of all. Water, therefore, is but ice kept in continual fufion; and ftill returning to its former ftate, when the heat is taken away. Between thefe oppofite opinions, the controverfy has been carried on with great ardour; much has been written on both fides; and yet, when we come to examine the debate, it will probably terminate in this queftion, whether cold or heat

firſt began their operations upon water? This is a fact of very little importance, if known; and what is more, it is a fact we can never know.

Indeed, if we examine into the operations of cold and heat upon water, we ſhall find that they produce ſomewhat ſimilar effects. Water dilates in its bulk, by heat, to a very conſiderable degree; and, what is more extraordinary, it is likewiſe dilated by cold in the ſame manner.

If water be placed over a fire, it grows gradually larger in bulk, as it becomes hot, until it begins to boil; after which, no art can either encreaſe its bulk, or its heat. By encreaſing the fire, indeed, it may be more quickly evaporated away; but its heat, and its bulk, ſtill continue the ſame. By the expanding of this fluid by heat, philoſophers have found a way to determine the warmth or the coldneſs of other bodies: for if put into a glaſs tube, by its ſwelling and riſing, it ſhews the quantity of heat in the body to which it is applied; and by its contracting, and ſinking, it ſhews the abſence of the ſame. Inſtead of uſing water in this inſtrument, which is called a thermometer, they now make uſe of ſpirit of wine, which is not apt to freeze, and which is endued even with a

greater expansion, by heat, than water. The instrument consists of nothing more than a hollow ball of glass, with a long tube growing out of it. This being partly filled with spirits of wine, tinctured red, so as to be seen when it rises, the ball is plunged into boiling water, which making the spirit within expand and rise in the tube, the water marks the greatest height to which it ascends; at this point the tube is to be broken off, and then hermetically sealed, by melting the glass with a blow-pipe: a scale being placed by the side, completes the thermometer. Now as the fluid expands or condenses with heat or cold, it will rise and fall in the tube in proportion; and the degree or quantity of ascent or descent will be seen in the scale.

No fire, as was said, can make water hotter, after it begins to boil. We can, therefore, at any time be sure of an equable certain heat; which is that of boiling water, which is invariably the same. The certainty of such an heat is not less useful than the instrument that measures it. It affords a standard, fixed, degree of heat over the whole world; boiling water being as hot in Greenland, as upon the coasts of Guinea. One fire is more intense than another: of heat there are various degrees; but boiling water is an heat every where the same, and easily procurable.

As heat thus expands water; so cold, when it is violent enough to freeze the same, produces exactly the same effect, and expands it likewise. Thus water is acted upon in the same manner by two opposite qualities; being dilated by both. As a proof that it is dilated by cold, we have only to observe the ice floating on the surface of a pond, which it would not do were it not dilated, and grown more bulky, by freezing, than the water, which remains unfroze. Mr. Boyle, however, put the matter past a doubt, by a variety of experiments *. Having poured a proper quantity of water into a strong earthen vessel, he exposed it, uncovered, to the open air, in frosty nights; and observed, that continually the ice reached higher than the water, before it was frozen. He filled also a tube with water, and stopped both ends with wax: the water, when froze, was found to push out the stopples from both ends; and a rod of ice appeared at each end of the tube, which shewed how much it was swollen by the cold within.

From hence, therefore, we may be very certain of the cold's dilating of the water; and experience also shews, that the force of this expansion has been found as great as any which

* Boyle, vol. i. p. 610.

heat has heen found to produce. The touch-hole of a ſtrong gun barrel being ſtopped, and a plug of iron forcibly driven into the muzzle, after the barrel had been filled with water, it was placed in a mixture of ice and ſalt: the plug, though ſoldered to the barrel, at firſt gave way, but being fixed in more firmly, within a quarter of an hour the gun-barrel burſt with a loud noiſe, and blew up the cover of the box wherein it lay. Such is its force in an ordinary experiment. But it has been known to burſt cannons, filled with water, and then left to freeze; for the cold congealing the water, and the ice ſwelling, it became irreſiſtible. The burſting of rocks, by froſt, which is frequent in the Northern climates, and is ſometimes ſeen in our own, is an equal proof of the expanſion of congealed water; for having, by ſome means, inſinuated itſelf into the body of the rock, it has remained there till the cold was ſufficient to affect it by congelation. But when once frozen, no obſtacle is able to confine it from dilating; and, if it cannot otherwiſe find room, the rock muſt burſt aſunder.

This alteration in the bulk of water, might have ſerved as a proof that it was capable of being compreſſed into a narrower ſpace than it occupied before; but, till of late, water was

held to be incompreffible. The general opinion was, that no art whatfoever could fqueeze it into a narrower compafs; that no power on earth, for inftance, could force a pint of water into a veffel that held an hair's breadth lefs than a pint. And this, faid they, appears from the famous Florentine experiment; where the water, rather than fuffer compreffure, was feen to ooze through the pores of the folid metal; and, at length, making a cleft in the fide, fpun out with great vehemence. But later trials have proved that water is very compreffible, and partakes of that elafticity which every other body poffeffes in fome degree. Indeed, had not mankind been dazzled by the brilliancy of one inconclufive experiment, there were numerous reafons to convince them of its having the fame properties with other fubftances. Ice, which is water in another ftate, is very elaftic. A ftone flung flantingly along the furface of a pond, bounds from the water feveral times; which fhews it to be elaftic alfo. But the trials of Mr. Canton have put this paft all doubt; which being fomewhat fimilar to thofe of the great Boyle, who preffed it with weights properly applied, carry fufficient conviction.

What has been hitherto related, is chiefly applicable to the element of water alone; but its fluidity is a property that it poffeffes in com-

mon with ſeveral other ſubſtances, in other reſpects greatly differing from it. That quality which gives riſe to the definition of a fluid, namely, that its parts are in a continual inteſtine motion, ſeems extremely applicable to water. What the ſhapes of thoſe parts are, it would be vain to attempt to diſcover. Every trial only ſhews the futility of the attempt; all we find is, that they are extremely minute; and that they roll over each other with the greateſt eaſe. Some, indeed, from this property alone, have not heſitated to pronounce them globular; and we have, in all our hydroſtatical books, pictures of theſe little globes in a ſtate of ſliding and rolling over each other. But all this is merely the work of imagination; we know that ſubſtances of any kind, reduced very ſmall, aſſume a fluid appearance, ſomewhat reſembling that of water. Mr. Boyle, after finely powdering and ſifting a little dry powder of plaiſter of Paris, put it in a veſſel over the fire, where it ſoon began to boil like water, exhibiting all the motions and appearances of a boiling liquor. Although but a powder, the parts of which we know are very different from each other, and juſt as accident has formed them, yet it heaved in great waves, like water. Upon

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agitation, an heavy body will ſink to the bottom, and a light one emerge to the top. There is no reaſon to ſuppoſe the figure of the parts of water round, ſince we ſee their fluidity very well imitated by a compoſition, the parts of which are of various forms and ſizes. The ſhape of the parts of water, therefore, we muſt be content to continue ignorant of. All we know is, that earth, air, and fire, conduce to ſeparate the parts from each other.

Earthy ſubſtances divide the parts from each other, and keep them aſunder. This diviſion may be ſo great, that the water will entirely loſe its fluidity thereby. Mud, potter's clay, and dried bricks, are ſo many different combinations of earth and water; each ſubſtance in which the parts of water are moſt ſeparated from each other, appearing to be the moſt dry. In ſome ſubſtances, indeed, where the parts of water are greatly divided, as in porcelane, for inſtance, it is no eaſy matter to recover and bring them together again; but they continue in a manner fixed and united to the manufactured clay. This circumſtance led Doctor Cheney into a very peculiar ſtrain of thinking. He ſuſpected that the quantity of water, on the ſurface of the earth, was daily decreaſing. For, ſays he, ſome parts of it are continually

joined to vegetable, animal, and mineral ſubſtances, which no art can again recover. United with theſe, the water loſes its fluidity; for if, continues he, we ſeparate a few particles of any fluid, and faſten them to a ſolid body, or keep them aſunder, they will be fluid no longer. To produce fluidity, a conſiderable number of ſuch particles are required; but here they are cloſe, and deſtitute of their natural properties. Thus, according to him, the world is growing every day harder and harder, and the earth firmer and firmer; and there may come a time when every object around us may be ſtiffened in univerſal frigidity! However, we have cauſes enough of anxiety in this world already, not to add this prepoſterous concern to the number.

That air alſo contributes to divide the parts of water, we can have no manner of doubt; ſome have even diſputed whether water be not capable of being turned into air. Though this cannot be allowed, it muſt be granted, that it may be turned into a ſubſtance which greatly reſembles air (as we have ſeen in the experiment of the æolipile) with all its properties; except that, by cold, this new-made air may be condenſed again into water.

But of all the ſubſtanees which tend to divide

the parts of water, fire is the moſt powerful. Water, when heated into ſteam, acquires ſuch force, and the parts of it tend to fly off from each other with ſuch violence, that no earthly ſubſtance we know of, is ſtrong enough to confine them. A ſingle drop of water, converted into ſteam, has been found capable of raiſing a weight of twenty tons; and would have raiſed twenty thouſand, were the veſſel confining it ſufficiently ſtrong, and the fire below encreaſed in proportion.

From this eaſy yielding of its parts to external preſſure, ariſes the art of determining the ſpecific gravity of bodies by plunging them in water; with many other uſeful diſcoveries in that part of natural philoſophy, called hydroſtatics. The laws of this ſcience, which Archimedes began, and Paſcal, with ſome other of the moderns, have improved, rather belongs to experimental than to natural hiſtory. However, I will take leave to mention ſome of the moſt ſtriking paradoxes in this branch of ſcience, which are as well confirmed by experiment, as rendered univerſal by theory. It would, indeed, be unpardonable, while diſcourſing on the properties of water, to omit giving ſome account of the manner in which it ſuſtains ſuch immenſe bulks as we ſee floating upon its ſoft and yielding ſurface: how ſome bodies, that are known

to ſink at one time, ſwim with eaſe, if their ſurface be enlarged: how the heavieſt body, even gold itſelf, may be made to ſwim upon water; and how the lighteſt, ſuch as cork, ſhall remain ſunk at the bottom: how the pouring in of a ſingle quart of water, will burſt an hogſhead hooped with iron: and how it aſcends, in pipes, from the valley, to travel over the mountain: theſe are circumſtances that are at firſt ſurpriſing; but, upon a ſlight conſideration, loſe their wonder.

* In order to conceive the manner in which all theſe wonders are effected, we muſt begin by obſerving that water is poſſeſſed of an invariable property, which has not hitherto been mentioned; that of always keeping its ſurface level and even. Winds, indeed, may raiſe it into waves; or art ſpurt it up in fountains; but ever, when left to itſelf, it ſinks into a ſmooth even ſurface, of which no one part is higher than another. If I ſhould pour water, for inſtance, into the arm of a pipe of the ſhape of the letter U, the fluid would riſe in the other arm juſt to the ſame height; becauſe, otherwiſe, it would not finds its level, which it invariably maintains. A pipe

* In the above ſketch, the manner of demonſtrating uſed by Monſieur D'Alembert is made uſe of, as the moſt obvious, and the moſt ſatiſfactory. Vide Eſſai ſur, &c.

bending from one hill down into the valley, and rising by another, may be confidered as a tube of this kind, in which the water, finking in one arm, rifes to maintain its level in the other. Upon this principle all water-pipes depend; which can never raife the water higher than the fountain from which they proceed.

Again, let us fuppofe for a moment, that the arms of the pipe already mentioned, may be made long or fhort at pleafure; and let us ftill further fuppofe, that there is fome obftacle at the bottom of it, which prevents the water poured into one arm, from rifing in the other. Now it is evident, that this obftacle at the bottom will fuftain a preffure from the water in one arm, equal to what would make it rife in the other; and this preffure will be great, in proportion as the arm filled with water is tall. We may, therefore, generally conclude, that the bottom of every veffel is preffed by a force, in proportion to the height of the water in that veffel. For inftance, if the veffel filled with water be forty feet high, the bottom of that veffel will fuftain fuch a preffure as would raife the fame water forty feet high, which is very great. From hence we fee how extremely apt our pipes that convey water to the city are to burft; for defcending from an hill of more than

forty feet high, they are preſſed by the water contained in them, with a force equal to what would raiſe it more than forty feet high; and that this is ſometimes able to burſt a wooden pipe, we can have no room to doubt of.

Still recurring to our pipe, let us ſuppoſe one of its arms ten times as thick as the other; this will produce no effect whatſoever upon the obſtacle below, which we ſuppoſed hindering its riſe in the other arm; becauſe, how thick ſoever the pipe may be, its contents would only riſe to its own level; and it will, therefore, preſs the obſtacle with an equal force. We may, therefore, univerſally conclude, that the bottom of any veſſel is preſſed by its water, not as it is broad or narrow, but in proportion as it is high. Thus the water contained in a veſſel not thicker than my finger, preſſes its bottom as forcibly as the water contained in an hogſhead of an equal height; and, if we made holes in the bottoms of both, the water would burſt out as forceful from the one as the other. Hence we may, with great eaſe, burſt an hogſhead with a ſingle quart of water, and it has been often done. We have only *, for this, to place an hogſhead on one end, filled with water: we then bore an hole in its top, into which we plant a narrow

* Nollet's Lectures.

tin pipe, of about thirty feet high: by pouring a quart of water into this, at the top, as it continues to riſe higher in the pipe, it will preſs more forcibly on the bottom and ſides of the hogſhead below, and at laſt burſt it.

Still returning to our ſimple inſtrument of demonſtration. If we ſuppoſe the obſtacle at the bottom of the pipe to be moveable, ſo as that the force of the water can puſh it up into the other arm; ſuch a body is quickſilver, for inſtance. Now, it is evident, that the weight of water weighing down upon this quickſilver in one arm, will at laſt preſs it up in the other arm; and will continue to preſs it upwards, until the fluid in both arms be upon a par. So that here we actually ſee quickſilver, the heavieſt ſubſtance in the world, except gold, floating upon water, which is but a very light ſubſtance.

When we ſee water thus capable of ſuſtaining quickſilver, we need not be ſurpriſed that it is capable of floating much lighter ſubſtances, ſhips, animals, or timber. When any thing floats upon water, we always ſee that a part of it ſinks in the ſame. A cork, a ſhip, a buoy, each buries itſelf a bed on the ſurface of the water; this bed may be conſidered as ſo much water diſplaced; the water will, therefore, loſe

ſo much of its own weight as is equal to the weight of that bed of water which it diſplaces. If the body be heavier than a ſimilar bulk of water, it will ſink; if lighter, it will ſwim. Univerſally, therefore, a body plunged in water, loſes as much of its weight as is equal to the weight of a body of water of its own bulk. Some light bodies, therefore, ſuch as cork, loſe much of their weight, and therefore ſwim; other more ponderous bodies ſink, becauſe they are heavier than their bulk of water.

Upon this ſimple theorem entirely depends the art of weighing metals hydroſtatically. I have a guinea, for inſtance, and deſire to know whether it be pure gold: I have weighed it in the uſual way with another guinea, and find it exactly of the ſame weight, but ſtill I have ſome ſuſpicion, from its greater bulk, that it is not pure. In order to determine this, I have nothing more to do than to weigh it in water with that ſame guinea that I know to be good, and of the ſame weight; and this will inſtantly ſhew the difference; for the true ponderous metal will ſink, and the falſe bulky one will be ſuſtained in proportion to the greatneſs of its ſurface. Thoſe whoſe buſineſs it is to examine the purity of metals, have a balance made for this purpoſe,

by which they can precisely determine which is most ponderous, or, as it is expressed, which has the greatest specific gravity. Seventy-one pound and an half of quicksilver is found to be equal in bulk to an hundred pound weight of gold. In the same proportion, sixty of lead, fifty-four of silver, forty-seven of copper, forty-five of brass, forty-two of iron, and thirty-nine of tin, are each equal to an hundred pound of the most ponderous of all metals.

This method of precisely determining the purity of gold, by weighing in water, was first discovered by Archimedes, to whom mankind have been indebted for many useful discoveries. Hiero, king of Sicily, having sent a certain quantity of gold to be made into a crown, the workman, it seems, kept a part for his own use, and supplied the deficiency with a baser metal. His fraud was suspected by the king, but could not be detected, till he applied to Archimedes, who weighed the crown in water; and, by this method, informed the king of the quantity of gold which was taken away.

It has been said, that all fluids endeavour to preserve their level; and, likewise, that a body pressing on the surface, tended to destroy that level. From hence it will easily be

inferred, that the deeper any body ſinks, the greater will be the reſiſtance of the depreſſed fluid beneath. It will be aſked, therefore, as the reſiſtance encreaſes in proportion as the body deſcends, how comes the body, after it is got a certain way, to ſink at all? The anſwer is obvious. From the fluid above preſſing it down with almoſt as great a force as the fluid beneath preſſes it up. Take away, by any art, the preſſure of the fluid from above, and let only the reſiſtance of the fluid from below be ſuffered to act, and after the body is got down very deep, the reſiſtance will be inſuperable. To give an inſtance: a ſmall hole opens in the bottom of a ſhip at ſea, forty feet we will ſuppoſe below the ſurface of the water; through this the water burſts up with great violence; I attempt to ſtop it with my hand, but it puſhes the hand violently away. Here the hand is, in fact, a body attempting to ſink upon water, at a depth of forty feet, with the preſſure from above taken away. The water, therefore, will overcome my ſtrength; and will continue to burſt in till it has got to its level: if I ſhould then dive into the hold, and clap my hand upon the opening, as before, I ſhould perceive no force acting againſt my hand at all, for the water above preſſes the hand as much down againſt the hole, as the water without

presses it upward. For this reason, also, when we dive to the bottom of the water, we sustain a very great pressure from above, it is true, but it is counteracted by the pressure from below; and the whole acting uniformly on the surface of the body, wraps us close round without injury.

As I have deviated thus far, I will just mention one or two properties more, which water, and all such like fluids, is found to possess. And first, their ascending in vessels which are emptied of air, as in our common pumps for instance. The air, however, being the agent in this case, we must previously examine its properties, before we undertake the explanation. The other property to be mentioned is, that of their ascending in small capillary tubes. This is one of the most extraordinary and inscrutable appearances in nature. Glass tubes may be drawn, by means of a lamp, as fine as an hair; still preserving their hollow within. If one of these be planted in a vessel of water, or spirit of wine, the liquor will immediately be seen to ascend; and it will rise higher, in proportion as the tube is smaller; a foot, two feet, and more. How does this come to pass? Is the air the cause? No: the liquor rises, although the air be taken away. Is attraction the cause?

No: for quickſilver does not aſcend, which it otherwiſe would. Many have been the theories of experimental philoſophers to explain this property. Such as are fond of travelling in the regions of conjecture, may conſult Hawkſbee, Morgan, Jurin, or Watſon, who have examined the ſubject with great minuteneſs. Hitherto, however, nothing but doubts inſtead of knowlege have been the reſult of their enquiries. It will not, therefore, become us to enter into the minuteneſs of the enquiry, when we have ſo many greater wonders to call our attention away.

CHAP. XIV.

Of the Origin of Rivers.

THE ſun ariſeth, and the ſun goeth down, and pants for the place from whence he aroſe. All things are filled with labour, and man cannot utter it. All rivers runs into the ſea, yet the ſea is not full. Unto the place whence the rivers come, thither they return again. The eye is not ſatisfied with ſeeing, nor the ear with hearing*. Thus ſpeaks the wiſeſt of the Jews.

* Eccleſiaſtes, chap. i. v. 5, 7, 8.

And, at so early a period was the curiosity of man employed in observing these great circulations of nature. Every eye attempted to explain those appearances; and every philosopher who has long thought upon the subject, seems to give a peculiar solution. The enquiry whence rivers are produced; whence they derive those unceasing stores of water, which continually enrich the world with fertility and verdure; has been variously considered; and divided the opinions of mankind, more than any other topic in natural history.

In this contest, the various champions may be classed under two leaders, Mr. De La Hire, who contends that rivers must be supplied from the sea, strained through the pores of the earth; and Doctor Halley, who has endeavoured to demonstrate, that the clouds alone are sufficient for the supply. Both sides have brought in mathematics to their aid; and have shewn, that long and laborious calculations can at any time be made, to obscure both sides of a question.

De La Hire * begins his proofs, that rain-water, evaporated from the sea, is insufficient for the production of rivers; by shewing, that rain never penetrates the surface of the earth above sixteen inches. From thence he infers,

* Hist. de l'Acad. 1713, p. 56.

that it is impoſſible for it, in many caſes, to ſink ſo as to be found at ſuch conſiderable depths below. Rain-water, he grants, is often ſeen to mix with rivers, and to ſwell their currents; but a much greater part of it evaporates. In fact, continues he, if we ſuppoſe the earth every where covered with water, evaporation alone would be ſufficient to carry off two feet nine inches of it in a year: and yet, we very well know, that ſcarce nineteen inches of rain-water falls in that time; ſo that evaporation would carry off a much greater quantity than is ever known to deſcend. The ſmall quantity of rain-water that falls is therefore but barely ſufficient for the purpoſes of vegetation. Two leaves of a fig-tree have been found, by experiment, to imbibe from the earth, in five hours and an half, two ounces of water. This implies the great quantity of fluid that muſt be exhauſted in the maintenance of one ſingle plant. Add to this, that the waters of the river Rungis will, by calculation, riſe to fifty inches; and the whole country from whence they are ſupplied, never receives fifty inches, in the year, by rain. Beſides this, there are many ſalt ſprings, which are known to proceed immediately from the ſea, and are ſubject to its flux and reflux. In ſhort, wherever we dig beneath

the ſurface of the earth, except in a very few inſtances, water is to be found,; and it is by this ſubterraneous water, that ſprings and rivers, nay, a great part of vegetation itſelf, is ſupported. It is this ſubterraneous water, which is raiſed into ſteam, by the internal heat of the earth, that feeds plants. It is this ſubterraneous water that diſtils through its interſtices; and there cooling, forms fountains. It is this that, by the addition of rains, is encreaſed into rivers; and pours plenty over the whole earth.

On the other ſide of the queſtion *, it is aſſerted, that the vapours which are exhaled from the ſea, and driven by the winds upon land, are more than ſufficient to ſupply not only plants with moiſture, but alſo, to furniſh a ſufficiency of water to the greateſt rivers. For this purpoſe, an eſtimate has been made of the quantity of water emptied at the mouth of the greateſt rivers; and of the quantity alſo raiſed from the ſea by evaporation; and it has been found, that the latter by far exceeds the former. This calculation was made by Mr. Mariotte. By him it was found, upon receiving ſuch rain as fell in a year, in a proper veſſel, fitted for that purpoſe, that, one year with another, there might fall about twenty inches of water upon

* Phil. Tranſ. vol. ii. p. 128.

the ſurface of the earth, throughout Europe. It was alſo computed, that the river Seine, from its ſource to the city of Paris, might cover an extent of ground, that would ſupply it annually with above ſeven millions of cubic feet of this water, formed by evaporation. But, upon computing the quantity which paſſed through the arches of one of its bridges in a year, it was found to amount only to two hundred and eighty millions of cubic feet, which is not above the ſixth part of the former number. Hence it appears, that this river may receive a ſupply brought to it by the evaporated waters of the ſea, ſix times greater than what it gives back to the ſea by its current; and, therefore, evaporation is more than ſufficient for maintaining the greateſt rivers; and ſupplying the purpoſes alſo of vegetation.

In this manner the ſea furniſhes ſufficient humidity to the air for furniſhing the earth with all neceſſary moiſture. One part of its vapours fall upon its own boſom, before they arrive upon land. Another part is arreſted by the ſides of mountains, and is compelled, by the riſing ſtream of air, to mount upward towards the ſummits. Here it is preſently precipitated, dripping down by the crannies of the ſtone. In ſome places, entering into the caverns of the

mountain, it gathers in thoſe receptacles, which being once filled, all the reſt overflows; and breaking out by the ſides of the hills, forms ſingle ſprings. Many of theſe run down by the vallies, or guts between the ridges of the mountain, and form little rivulets or brooks; many of theſe meeting in one common valley, and gaining the plain ground, being grown leſs rapid, become a river: and many of theſe uniting, make ſuch vaſt bodies of water as the Rhine, the Rhone, and the Danube.

There is ſtill a third part, which falls upon the lower grounds, and furniſhes plants with their wonted ſupply. But the circulation does not reſt even here; for it is again exhaled into vapour by the action of the ſun; and afterwards returned to that great maſs of waters whence it firſt aroſe. This, adds Doctor Halley, ſeems the moſt reaſonable hypotheſis; and much more likely to be true, than that of thoſe who derive all ſprings from the filtering of the ſea waters through certain imaginary tubes or paſſages within the earth; ſince it is well known, that the greateſt rivers have their moſt copious fountains the moſt remore from the ſea *.

This ſeems the moſt general opinion; and yet, after all, it is ſtill preſſed with great diffi-

* Phil. Tranſ. vol. ii. p. 128.

culties; and there is ſtill room to look out for a better theory. The perpetuity of many ſprings, which always yield the ſame quantity when the leaſt rain or vapour is afforded, as well as when the greateſt, is a ſtrong objection. Derham* mentions a ſpring at Upminſter, which he could never perceive by his eye to be diminiſhed, in the greateſt droughts, even when all the ponds in the country, as well as an adjoining brook, have been dry for ſeveral months together. In the rainy ſeaſons alſo, it was never overflowed; except ſometimes, perhaps, for an hour or ſo, upon the immiſſion of the external rains. He, therefore, juſtly enough concludes, that had this ſpring its origin from rain or vapour, there would be found an encreaſe or decreaſe of its water, correſponding to the cauſes of its production.

Thus the reader, after having been toſſed from one hypotheſis to another, muſt at laſt be contented to ſettle in conſcious ignorance. All that has been written upon this ſubject, affords him rather ſomething to ſay, than ſomething to think; ſomething rather for others than for himſelf. Varenius, indeed, although he is at a loſs for the origin of rivers, is by no means ſo as to their formation. He is pretty poſitive that all

* Derham Phyſico-Theol.

rivers are artificial. He boldly afferts, that their channels have been originally formed by the induftry of man. His reafons are, that when a new fpring breaks forth, the water does not make itfelf a new channel, but fpreads over the adjacent land. Thus, fays he, men are obliged to direct its courfe; or, otherwife, Nature would never have found one. He enumerates many rivers, that are certainly known, from hiftory, to have been dug by men. He alledges, that no falt-water rivers are found, becaufe men did not want falt-water; and as for falt, that was procurable at a lefs expence than digging a river for it. However, it cofts a fpeculative man but a fmall expence of thinking to form fuch an hypothefis. It may, perhaps, engrofs the reader's patience to detain him longer upon it.

Neverthelefs, though philofophy be thus ignorant, as to the production of rivers, yet the laws of their motion, and the nature of their currents, have been very well explained. The Italians have particularly diftinguifhed themfelves in this refpect; and it is chiefly to them that we are indebted for the improvement *.

All rivers have their fource either in mountains, or elevated lakes; and it is in their defcent

* S. Guglielmini della Natura de Fiumi, paffim.

from theſe, that they acquire that velocity which maintains their future current. At firſt their courſe is generally rapid and headlong; but it is retarded in its journey by the continual friction againſt its banks, by the many obſtacles it meets to divert its ſtream, and by the plains generally becoming more level as it approaches towards the ſea.

If this acquired velocity be quite ſpent, and the plain through which the river paſſes is entirely level, it will, notwithſtanding, ſtill continue to run from the perpendicular preſſure of the water, which is always in exact proportion to the depth. This perpendicular preſſure is nothing more than the weight of the upper waters preſſing the lower out of their places, and, conſequently, driving them forward, as they cannot recede againſt the ſtream. As this preſſure is greateſt in the deepeſt parts of the river, ſo we generally find the middle of the ſtream moſt rapid; both becauſe it has the greateſt motion thus communicated by the preſſure, and the feweſt obſtructions from the banks on either ſide.

Rivers thus ſet into motion are almoſt always found to make their own beds. Where they find the bed elevated, they wear its ſubſtance away, and depoſit the ſediment in the next hol-

low, fo as in time to make the bottom of their channels even. On the other hand, the water is continually gnawing and eating away the banks on each fide; and this with more force as the current happens to ftrike more directly againft them. By thefe means, it always has a tendency to render them more ftrait and parallel to its own courfe. Thus it continues to rectify its banks, and enlarge its bed; and, confequently, to diminifh the force of its ftream, till there becomes an equilibrium between the force of the water, and the refiftance of its banks, upon which both will remain without any further mutation. And it is happy for man that bounds are thus put to the erofion of the earth by water; and that we find all rivers only dig and widen themfelves but to a certain degree *.

In thofe plains † and large vallies where great rivers flow, the bed of the river is ufually lower than any part of the valley. But it often happens, that the furface of the water is higher than many of the grounds that are adjacent to the banks of the ftream. If, after inundations, we take a view of fome rivers, we fhall find their banks appear above water, at a time that all

* Guglielmini della Natura de Fiumi, paffim.

† Buffon. De Fleuves, paffim, vol. ii.

the adjacent valley is overflown. This proceeds from the frequent depoſition of mud, and ſuch like ſubſtances, upon the banks, by the rivers frequently overflowing; and thus, by degrees, they become elevated above the plain; and the water is often ſeen higher alſo.

Rivers, as every body has ſeen, are always broadeſt at the mouth; and grow narrower towards their ſource. But what is leſs known, and probably more deſerving curioſity, is, that they run in a more direct channel as they immediately leave their ſources; and that their ſinuoſities and turnings become more numerous as they proceed. It is a certain ſign among the ſavages of North America, that they are near the ſea, when they find the rivers winding, and every now and then changing their direction. And this is even now become an indication to the Europeans themſelves, in their journies through thoſe trackleſs foreſts. As thoſe ſinuoſities, therefore, encreaſe as the river approaches the ſea, it is not to be wondered at, that they ſometimes divide, and thus diſembogue by different channels. The Danube diſembogues into the Euxine by ſeven mouths; the Nile, by the ſame number; and the Wolga, by ſeventy.

The currents * of rivers are to be eſtimated very differently from the manner in which thoſe writers, who have given us mathematical theories on this ſubject, repreſent them. They found their calculations upon the ſurface being a perfect plain, from one bank to the other: but this is not the actual ſtate of Nature; for rivers, in general, riſe in the middle; and this convexity is greateſt in proportion as the rapidity of the ſtream is greater. Any perſon, to be convinced of this, need only lay his eye as nearly as he can on a level with the ſtream, and looking acroſs to the oppoſite bank, he will perceive the river in the midſt to be elevated conſiderably above what it is at the edges. This riſing, in ſome rivers, is often found to be three feet high; and is ever encreaſed, in proportion to the rapidity of the ſtream. In this caſe, the water in the midſt of the current loſes a part of its weight, from the velocity of its motion; while that at the ſides, for the contrary reaſon, ſinks lower. It ſometimes, however, happens, that this appearance is reverſed; for when tides are found to flow up with violence againſt the natural current of the water, the greateſt rapidity is then found at the ſides of the river, as the

* Buffon. De Fleuves, paſſim, vol. II.

water there leaſt reſiſts the influx from the ſea. On thoſe occaſions, therefore, the river preſents a concave rather than a convex ſurface: and, as in the former caſe, the middle waters roſe in a ridge; in this caſe, they ſink in a furrow.

The ſtream of all rivers is more rapid in proportion as its channel is diminiſhed. For inſtance, it will be much ſwifter where it is ten yards broad, than where it is twenty; for the force behind ſtill puſhing the water forward, when it comes to the narrow part, it muſt make up by velocity what it wants in room.

It often happens that the ſtream of a river is oppoſed by one of its jutting banks, by an iſland in the midſt, the arches of a bridge, or ſome ſuch obſtacle. This produces, not unfrequently, a back current; and the water having paſt the arch with great velocity, puſhes the water on each ſide of its direct current. This produces a ſide current, tending to the bank; and not unfrequently a whirlpool; in which a large body of waters are circulated in a kind of cavity, ſinking down in the middle. The central point of the whirlpool is always loweſt, becauſe it has the leaſt motion: the other parts are ſupported, in ſome meaſure, by the violence of theirs; and, conſequently, riſe higher as their motion is greater; ſo that towards the extremity of the

whirlpool muſt be higher than towards the center.

If the ſtream of a river be ſtopped at the ſurface, and yet be free below; for inſtance, if it be laid over by a bridge of boats, there will then be a double current; the water at the ſurface will flow back, while that at the bottom will proceed with increaſed velocity. It often happens that the current at the bottom is ſwifter than at the top, when, upon violent land-floods, the weight of waters towards the ſource preſſes the waters at the bottom, before it has had time to communicate its motion to the ſurface. However, in all other caſes, the ſurface of the ſtream is ſwifter than the bottom, as it is not retarded by rubbing over the bed of the river.

It might be ſuppoſed that bridges, dams, and other obſtacles in the current of a river, would retard its velocity. But the difference they make is very inconſiderable. The water, by theſe ſtoppages, gets an elevation above the object; which, when it has ſurmounted, it gives a velocity that recompenſes the former delay. Iſlands and turnings alſo retard the courſe of the ſtream but very inconſiderably; any cauſe which diminiſhes the quantity of the water, moſt ſenſibly diminiſhes the force and the velocity of the ſtream.

An encreafe * of water in the bed of the river, always encreafes its rapidity; except in cafes of inundation. The inftant the river has overflowed its banks, the velocity of its current is always turned that way, and the inundation is perceived to continue for fome days; which it would not otherwife do, if, as foon as the caufe was difcontinued, it acquired its former rapidity.

A violent ftorm, that fets directly up againft the courfe of the ftream, will always retard, and fometimes entirely ftop its courfe. I have feen an inftance of this, when the bed of a large river was left entirely dry for fome hours, and fifh were caught among the ftones at the bottom.

Inundations are generally greater towards the fource of rivers, than farther down; becaufe the current is generally fwifter below than above; and that for the reafons already affigned.

A little river † may be received into a large one, without augmenting either its width or depth. This, which at firft view feems a paradox, is yet very eafily accounted for. The little river, in this cafe, only goes towards encreafing the fwiftnefs of the larger, and putting its dormant waters into motion. In this man-

* Buffon, vol. ii. p. 62. † Guglielmini, ibid.

ner, the Venetian branch of the Po was puſhed on by the Ferareſe branch and that of Panaro, without any enlargement of its breadth or depth from theſe acceſſions.

A river tending to enter another, either perpendicularly, or in an oppoſite direction, will be diverted, by degrees, from that direction; and be obliged to make itſelf a more favourable entrance downward, and more conſpiring with the ſtream of the former.

The union of two rivers into one, makes it flow the ſwifter; ſince the ſame quantity of water, inſtead of rubbing againſt four ſhores, now only rubs againſt two. And, beſides, the current being deeper, becomes of conſequence more fitted for motion.

With reſpect to the places from whence rivers proceed, it may be taken for a general rule, that the largeſt * and higheſt mountains ſupply the greateſt and moſt extenſive rivers. It may alſo be remarked, in whatever direction the ridge of the mountain runs, the river takes an oppoſite courſe. If the mountain, for inſtance, ſtretches from north to ſouth, the river runs from eaſt to weſt; and ſo contrariwiſe. Theſe are ſome of the moſt generally received opinions with regard to the courſe of rivers;

* Doctor Halley.

however, they are liable to many exceptions; and nothing but an actual knowledge of each particular river can furnish us with an exact theory of its current.

The largest rivers of Europe are, first, the Wolga, which is about six hundred and fifty leagues in length, extending from Reschow to Astrachan. It is remarkable of this river, that it abounds with water during the summer months of May and June; but all the rest of the year is so shallow as scarce to cover its bottom, or allow a passage for loaded vessels that trade up its stream. It was up this river that the English attempted to trade into Persia, in which they were so unhappily disappointed, in the year 1741. The next in order is the Danube. The course of this is about four hundred and fifty leagues, from the mountains of Switzerland to the Black Sea. It is so deep between Buda and Belgrade, that the Turks and Christians have fleets of men of war upon it, which frequently engaged, during the last war between the Ottomans and the Austrians: however, it is unnavigable further down, by reason of its cataracts, which prevent its commerce into the Black Sea. The Don, or Tanais, which is four hundred leagues from the source of that branch of it called the Sosna, to its mouth in the Euxine

sea. In one part of its course it approaches near the Wolga; and Peter the Great had actually begun a canal, by which he intended joining those two rivers; but this he did not live to finish. The Nieper, or Boristhenes, which rises in the middle of Muscovy, and runs a course of three hundred and fifty leagues, to empty itself into the Black Sea. The Old Cossacks inhabit the banks and islands of this river; and frequently cross the Black Sea, to plunder the maritime places on the coasts of Turky. The Dwina, which takes its rise in a province of the same name in Russia, that runs a course of three hundred leagues, and disembogues into the White Sea, a little below Archangel.

The largest rivers of Asia are, the Hoanho, in China, which is eight hundred and fifty leagues in length, computing from its source at Raja Ribron, to its mouth in the Gulph of Changi. The Jenisca of Tartary, about eight hundred leagues in length, from the Lake Selinga to the Icy Sea. This river is, by some, supposed to supply most of that great quantity of drift wood which is seen floating in the seas, near the Artic circle. The Oby, of five hundred leagues, running from the lake of Kila into the Northern sea. The Amour, in Eastern Tartary, whose course is about five hundred and seventy-five leagues, from its source to its

entrance into the ſea of Kamtſkatka. The Kiam, in China, five hundred and fifty leagues in length. The Ganges, one of the moſt noted rivers in the world, and about as long as the former. It riſes in the mountains which ſeparate India from Tartary; and running through the dominions of the Great Mogul, diſcharges itſelf by ſeveral mouths into the bay of Bengal. It is not only eſteemed by the Indians for the depth, and pureneſs of its ſtream, but for a ſuppoſed ſanctity which they believe to be in its waters. It is viſited annually by ſeveral hundred thouſand pilgrims, who pay their devotions to the river as to a god; for ſavage ſimplicity is always known to miſtake the bleſſings of the Deity for the Deity himſelf. They carry their dying friends from diſtant countries, to expire on its banks; and to be buried in its ſtream. The water is loweſt in April or May; but the rains beginning to fall ſoon after, the flat country is overflowed for ſeveral miles, till about the end of September; the waters then begin to retire, leaving a prolific ſediment behind, that enriches the ſoil, and, in a few days time, gives a luxuriance to vegetation, beyond what can be conceived by an European. Next to this may be reckoned the ſtill more celebrated river Euphrates. This riſes from two ſources, north-

ward of the city Erzerum, in Turcomania; and unites about three days journey below the ſame; from whence, after performing a courſe of five hundred leagues, it falls into the Gulph of Perſia, fifty miles below the city of Baſſora in Arabia. The river Indus is extended from its ſource to its diſcharge into the Arabian ſea, four hundred leagues.

The largeſt rivers of Africa are, the Senegal, which runs a courſe of not leſs than eleven hundred leagues, comprehending the Niger, which ſome have ſuppoſed to fall into it. However, later accounts ſeem to affirm that the Niger is loſt in the ſands, about three hundred miles up from the weſtern coaſts of Africa. Be this as it may, the Senegal is well known to be navigable for more than three hundred leagues up the country; and how much higher it may reach is not yet diſcovered, as the dreadful fatality of the inland parts of Africa, not only deter curioſity, but even avarice, which is a much ſtronger paſſion. At the end of laſt war, of fifty Engliſhmen that were ſent to the factory at Galam, a place taken from the French, and nine hundred miles up the river, only one returned to tell the fate of his companions, who were deſtroyed by the climate. The celebrated river Nile is ſaid to be nine hundred and ſeventy

leagues, from its ſource among the mountains of the Moon, in Upper Æthiopia, to its opening into the Mediterranean ſea. The ſources of this river were conſidered as inſcrutable by the ancients; and the cauſes of its periodical inundation were equally known. They have both been aſcertained by the miſſionaries who have travelled into the interior parts of Æthiopia. The Nile takes its riſe in the kingdom of Gojam *, from a ſmall aperture on the top of a mountain, which, though not above a foot and an half over, yet was unfathomable. This fountain, when arrived at the foot of the mountain, expands into a river; and, being joined by others, forms a lake thirty leagues long, and as many broad; from this, its channel, in ſome meaſure, winds back to the country where it firſt began; from thence, precipitating by frightful cataracts, it travels through a variety of deſart regions, equally formidable, ſuch as Amhara, Olaca, Damot, and Xaoa. Upon its arrival in the kingdom of Upper Egypt, it runs through a rocky channel, which ſome late travellers have miſtaken for its cataracts. In the beginning of its courſe, it receives many leſſer rivers into it; and Pliny was miſtaken, in ſaying that it received none. In the beginning alſo of its courſe, it

* Kircher Mund. Subt. vol. ii. p. 72.

has many windings; but, for above three hundred leagues from the ſea, runs in a direct line. Its annual overflowings ariſe from a very obvious cauſe, which is almoſt univerſal with the great rivers that take their ſource near the Line. The rainy ſeaſon, which is periodical in thoſe climates, flood the rivers; and as this always happens in our ſummer, ſo the Nile is at that time overflown. From theſe inundations, the inhabitants of Egypt derive happineſs and plenty; and, when the river does not ariſe to its accuſtomed heights, they prepare for an indifferent harveſt. It begins to overflow about the ſeventeenth of June; it generally continues to augment for forty days, and decreaſes in about as many more. The time of encreaſe and decreaſe, however, is much more inconſiderable now than it was among the ancients. Herodotus informs us, that it was an hundred days riſing, and as many falling; which ſhews that the inundation was much greater at that time than at preſent. Mr. Buffon* has aſcribed the preſent diminution, as well to the leſſening of the mountains of the Moon, by their ſubſtance having ſo long been waſhed down with the ſtream, as to the riſing of the earth in Egypt, that has for ſo many ages received this extraneous ſupply.

* Buffon, vol. ii. p. 82.

But we do not find, by the buildings that have remained ſince the times of the ancients, that the earth is much raiſed ſince then. Beſides the Nile in Africa, we may reckon the Zara, and the Coanza, from the greatneſs of whoſe openings into the ſea, and the rapidity of whoſe ſtreams, we form an eſtimate of the great diſtance from whence they come. Their courſes, however, are ſpent in watering deſarts and ſavage countries, whoſe poverty or fierceneſs have kept ſtrangers away.

But of all parts of the world, America, as it exhibits the moſt lofty mountains, ſo alſo it ſupplies the largeſt rivers. The foremoſt of theſe is the great river Amazons, which, from its ſource in the lake of Lauricocha, to its diſcharge into the Weſtern Ocean, performs a courſe of more than twelve hundred leagues*. The breadth and depth of this river is anſwerable to its vaſt length; and, where its width is moſt contracted, its depth is augmented in proportion. So great is the body of its waters, that other rivers, though before the objects of admiration, are loſt in its boſom. It proceeds, after their junction, with its uſual appearance, without any viſible change in its breadth or rapidity; and, if we may ſo expreſs

* Ulloa, vol. i. p. 388.

it, remains great without oftentation. In fome places it difplays its whole magnificence, dividing into feveral large branches, and encompaffing a multitude of iflands; and, at length, difcharging itfelf into the ocean, by a channel of an hundred and fifty miles broad. Another river, that may almoft rival the former, is the St. Lawrence, in Canada, which rifing in the lake Affiniboils, paffes from one lake to another, from Criftinaux to Alempigo; from thence to lake Superior; thence to the lake Hurons; to lake Erie; to lake Ontario; and, at laft, after a courfe of nine hundred leagues, pours their collected waters into the Atlantic ocean. The river Miffifippi is of more than feven hundred leagues in length, beginning at its fource near the lake Affiniboils, and ending at its opening into the Gulph of Mexico. The river Plate runs a length of more than eight hundred leagues from its fource in the river Parana, to its mouth. The river Oroonoko is feven hundred and fifty-five leagues in length, from its fource near Pafto, to its difcharge into the Atlantic ocean.

Such is the amazing length of the greateft rivers; and even in fome of thefe, the moft remote fources very probably yet continue unknown. In fact, if we confider the number of

rivers which they receive, and the little acquaintance we have with the regions through which they run, it is not to be wondered at that geographers are divided concerning the ſources of moſt of them. As among a number of roots by which nouriſhment is conveyed to a ſtately tree, it is difficult to determine preciſely that by which the tree is chiefly ſupplied; ſo among the many branches of a great river, it is equally difficult to tell which is the original. Hence it may eaſily happen, that a ſimilar branch is taken for the capital ſtream; and its runnings are purſued, and delineated, in prejudice of ſome other branch that better deſerved the name and the deſcription. In this manner *, in Europe, the Danube is known to receive thirty leſſer rivers: the Wolga, thirty-two or thirty-three. In Aſia, the Hohanno receives thirty-five; the Jeniſca above ſixty; the Oby as many; the Amour about forty; the Nanquin receives thirty rivers; the Ganges twenty; and the Euphrates about eleven. In Africa, the Senegal receives more than twenty rivers; the Nile receives not one for five hundred leagues upwards, and then only twelve or thirteen. In America, the river Amazons receives above ſixty, and thoſe very conſiderable; the river

* Buffon, vol. ii. p. 74.

St. Lawrence about forty, counting thoſe which fall into its lakes; the Miſſiſippi receives forty; and the river Plate above fifty.

I mentioned the inundations of the Ganges and the Nile, but almoſt every other great river whoſe ſource lies within the tropics, have their ſtated inundations alſo. The river Pegu has been called, by travellers, the Indian Nile, becauſe of the ſimilar overflowings of its ſtream: this it does to an extent of thirty leagues on each ſide; and ſo fertilizes the ſoil, that the inhabitants ſend great quantities of rice into other countries, and have ſtill abundance for their own conſumption. The river Senegal has likewiſe its inundations, which cover the whole flat country of Negroland, beginning and ending much about the ſame time with thoſe of the Nile; as, in fact, both rivers riſe from the ſame mountains. But the difference between the effects of the inundations in each river is remarkable: in the one, it diſtributes health and plenty; in the other, diſeaſes, famine, and death. The inhabitants along the torrid coaſts of the Senegal can receive no benefit from any additional manure the river may carry down to their ſoil, which is, by nature, more than ſufficiently luxuriant; or, even if they could, they have not induſtry to turn it to any advantage.

The banks, therefore, of the rivers, lie uncultivated, overgrown with rank and noxious herbage, and infested with thousands of animals of various malignity. Every new flood only tends to encrease the rankness of the soil, and to provide fresh shelter for the creatures that infest it. If the flood continues but a few days longer than usual, the improvident inhabitants, who are driven up in the higher grounds, want provisions, and a famine ensues. When the river begins to return into its channel, the humidity and heat of the air are equally fatal; and the carcases of infinite numbers of animals, swept away by the inundation, putrifying in the sun, produce a stench that is almost insupportable. But even the luxuriance of the vegetation becomes a nuisance. I have been assured, by persons of veracity who have been up the river Senegal, that there are some plants growing along the coast, the smell of which is so powerful, that it is hardly to be endured. It is certain, that all the sailors and soldiers who have been at any of our factories there, ascribe the unwholesomeness of the voyage up the stream, to the vegetable vapour. However this be, the inundations of the rivers in this wretched part of the globe, contribute scarce any advantage, if we except to the beauty of

the profpects which they afford. Thefe, indeed, are finifhed beyond the utmoft reach of art: a fpacious glaffy river, with its banks here and there fringed to the very furface by the mangrove-tree, that grows down into the water, prefents itfelf to view. Lofty forefts of various colours, with openings between, carpeted with green plants, and the moft gaudy flowers; beafts and animals, of various kinds, that ftand upon the banks of the river, and, with a fort of wild curiofity, furvey the mariners as they pafs, contribute to heighten the fcene. This is the fketch of an African profpect; which delights the eye, even while it deftroys the conftitution.

Befide thefe annually periodical inundations, there are many rivers that overflow at much fhorter intervals. Thus moft of thofe in Peru and Chili have fcarce any motion by night; but upon the appearance of the morning fun, they refume their former rapidity: this proceeds from the mountain fnows, which melting with the heat, encreafe the ftream, and continue to drive on the current while the fun continues to diffolve them. Some rivers alfo flow with an even fteady current, from their fource to the fea; others flow with greater rapidity, their ftream being poured down in a cataract, or fwallowed by the fands, before they reach the fea.

The rivers of thofe countries that have been leaft inhabited, are ufually more rocky, uneven, and broken into water-falls or cataracts, than thofe where the induftry of man has been more prevalent. Wherever man comes, nature puts on a milder appearance: the terrible and the fublime are exchanged for the gentle and the ufeful; the cataract is floped away into a placid ftream; and the banks become more fmooth and even *. It muft have required ages to render the Rhone or the Loir navigable; their beds muft have been cleaned and directed; their inequalities removed; and, by a long courfe of induftry, nature muft have been taught to confpire with the defires of her controller. Every one's experience muft have fupplied inftances of rivers thus being made to flow more evenly, and more beneficially to mankind; but there are fome whofe currents are fo rapid, and falls fo precipitate, that no art can obviate; and that muft for ever remain as amazing inftances of incorrigible nature.

Of this kind are the cataracts of the Rhine; one of which I have feen exhibit a very ftrange appearance; it was that at Schathaufen, which was frozen quite acrofs, and the water ftood in columns where the cataract had formerly fallen. The Nile, as was faid, has its cataracts. The

* Buffon, vol. ii. p. 90.

river Vologda, in Ruſſia, has two. The river Zara, in Africa, has one near its ſource. The river Velino, in Italy, has a cataract of above an hundred and fifty feet perpendicular. Near the city of Gottenburgh *, in Sweden, the river ruſhes down from a prodigious high precipice into a deep pit, with a terrible noiſe, and ſuch dreadful force, that thoſe trees deſigned for the maſts of ſhips, which are floated down the river, are uſually turned upſide down in their fall, and often are ſhattered to pieces, by being daſhed againſt the ſurface of the water in the pit; this occurs if the maſts fall ſideways upon the water; but if they fall endways, they dive ſo far under water, that they diſappear for a quarter of an hour, or more: the pit into which they are thus plunged, has been often ſounded with a line of ſome hundred fathoms long, but no ground has been found hitherto. There is alſo a cataract at Powerſcourt, in Ireland, in which, if I am rightly informed, the water falls three hundred feet perpendicular; which is a greater deſcent than that of any other cataract in any part of the world. There is a cataract at Albany, in the province of New York, which pours its ſtream fifty feet perpendicular. But of all the cataracts in the

* Phil. Tranſ. vol. ii. p. 325.

world, that of Niagara, in Canada, if we consider the great body of water that falls, must be allowed to be the greatest, and the most astonishing.

This amazing fall of water is made by the river St. Lawrence, in its passage from the lake Erie into the lake Ontario. We have already said that St. Lawrence was one of the largest rivers in the world; and yet the whole of its waters are here poured down, by a fall of an hundred and fifty feet perpendicular. It is not easy to bring the imagination to correspond with the greatness of the scene; a river extremely deep and rapid, and that serves to drain the waters of almost all North America into the Atlantic ocean, is here poured precipitately down a ledge of rocks, that rise, like a wall, across the whole bed of its stream. The width of the river, a little above, is near three quarters of a mile broad, and the rocks, where it grows narrower, are four hundred yards over. Their direction is not streight across, but hollowing inwards like an horse-shoe; so that the cataract, which bends to the shape of the obstacle, rounding inwards, presents a kind of theatre the most tremendous in nature. Just in the middle of this circular wall of waters, a little island, that has braved the fury of the current, presents one

of its points, and divides the ſtream at top into two; but it unites again long before it has got to the bottom. The noiſe of the fall is heard at ſeveral leagues diſtance; and the fury of the waters at the bottom of their fall is inconceivable. The daſhing produces a miſt that riſes to the very clouds; and that produces a moſt beautiful rainbow, when the ſun ſhines. It may eaſily be conceived, that ſuch a cataract quite deſtroys the navigation of the ſtream; and yet ſome Indiam canoes, as is is ſaid, have been known to venture down it with ſafety.

Of thoſe rivers that loſe themſelves in the ſands, or are ſwallowed up by chaſms in the earth, we have various information. What we are told by the ancients, of the river Alpheus, in Arcadia, that ſinks into the ground, and riſes again near Syracuſe, in Sicily, where it takes the name of Arethuſa, is rather more known than credited. But we have better information with reſpect to the river Tigris being loſt in this manner under Mount Taurus; of the Guadilquiver, in Spain, being buried in the ſands; of the river Greatah, in Yorkſhire, running underground, and riſing again; and even of the great Rhine itſelf, a part of which is no doubt loſt in the ſands, a little above Leyden. But it ought to be obſerved of this

river, that by much the greateſt part arrives at the ocean; for, although the ancient channel which fell into the ſea, a little to the weſt of that city, be now entirely choaked up, yet there are ſtill a number of ſmall canals, that carry a great body of waters to the ſea: and, beſides, it has alſo two very large openings, the Lech, and the Wal, below Rotterdam, by which it empties itſelf abundantly.

Be this as it will, nothing is more common in ſultry and ſandy deſerts, than rivers being thus either loſt in the ſands, or entirely dried up by the ſun. And hence we ſee, that under the Line, the ſmall rivers are but few; for ſuch little ſtreams as are common in Europe, and which with us receive the name of rivers, would quickly evaporate, in thoſe parching and extenſive deſerts. It is even confidently aſſerted, that the great river Niger is thus loſt before it reaches the ocean; and that its ſuppoſed mouths, the Gâmbia, and the Senegal, are diſtinct rivers, that come a vaſt way from the interior parts of the country. It appears, that the rivers under the Line are large; but it is otherwiſe at the Poles *, where they muſt neceſſarily be ſmall. In that deſolate region, as the mountains are covered with per-

* Krantz's Hiſtory of Greenland, vol. i. p. 41.

petual ice, which melts but little, or not at all, the ſprings and rivulets are furniſhed with a very ſmall ſupply. Here, therefore, men and beaſts would periſh, and die for thirſt, if Providence had not ordered, that in the hardeſt winter, thaws ſhould intervene, which depoſit a ſmall quantity of ſnow-water in pools under the ice; and from this ſource the wretched inhabitants drain a ſcanty beverage.

Thus, whatever quarter of the globe we turn to, we ſhall find new reaſons to be ſatisfied with that part of it in which we reſide. Our rivers furniſh all the plenty of the African ſtream, without its inundation; they have all the coolneſs of the Polar rivulet, with a more conſtant ſupply; they may want the terrible magnificence of huge cataracts, or extenſive lakes, but they are more navigable, and more tranſparent; though leſs deep and rapid than the rivers of the torrid zone, they are more manageable, and only wait the will of man to take their direction. The rivers of the torrid zone, like the monarchs of the country, rule with deſpotic tyranny, profuſe in their bounties, and ungovernable in their rage. The rivers of Europe, like their kings, are the friends, and not the oppreſſors of the people; bounded by known limits, abridged in the

power of doing ill, directed by human ſagacity, and only at freedom to diſtribute happineſs and plenty.

CHAP. XV.

Of the Ocean in general; and of its Saltneſs.

IF we look upon a map of the world, we ſhall find that the ocean occupies conſiderably more of the globe, than the land is found to do. This immenſe body of waters is diffuſed round both the Old and New Continent, to the ſouth; and may ſurround them alſo to the north, for what we know, but the ice in thoſe regions has ſtopped our enquiries. Although the ocean, properly ſpeaking, is but one extenſive ſheet of waters, continued over every part of the globe, without interruption, and although no part of it is divided from the reſt, yet geographers have diſtinguiſhed it by different names; as the Atlantic or Weſtern Ocean, the Northern Ocean, the Southern Ocean, the Pacific Ocean, and the Indian Ocean. Others have divided it differently, and given other names; as the Frozen Ocean, the Inferior Ocean, or the American Ocean. But all theſe being arbitrary diſtinctions, and not of Nature's making, the naturaliſt may conſider them with indifference.

In this vast receptacle, almost all the rivers of the earth ultimately terminate; nor do such great supplies seem to encrease its stores; for it is neither apparently swollen by their tribute, nor diminished by their failure; it still continues the same. Indeed, what is the quantity of water of all the rivers and lakes in the world, compared to that contained in this great receptacle *? If we should offer to make a rude estimate, we shall find that all the rivers in the world, flowing into the bed of the sea, with a continuance of their present stores, would take up at least eight hundred years to fill it to its present height. For, supposing the sea to be eighty-five millions of square miles in extent, and a quarter of a mile, upon an average, in depth, this, upon calculation, will give above twenty-one millions of cubic miles of water, as the contents of the whole ocean. Now, to estimate the quantity of water which all the rivers supply, take any one of them; the Po, for instance, the quantity of whose discharge into the sea, is known to be one cubic mile of water in twenty-six days. Now it will be found, upon a rude computation, from the quantity of ground the Po, with its influent streams, covers, that all the rivers of the world furnish about

* Buffon, vol. ii. p. 70.

two thoufand times that quantity of water. In the fpace of a year, therefore, they will have difcharged into the fea about twenty-fix thoufand cubic miles of water; and not till eight hundred years, will they have difcharged as much water as is contained in the fea at prefent. I have not troubled the reader with the odd numbers, left he fhould imagine I was giving precifion to a fubject that is incapable of it.

Thus great is the affemblage of waters diffufed round our habitable globe; and yet, immeafurable as they feem, they are moftly rendered fubfervient to the neceffities and the conveniencies of fo little a being as man. Neverthelefs, if it fhould be afked whether they be made for him alone, the queftion is not eafily refolved. Some philofophers have perceived fo much analogy to man in the formation of the ocean, that they have not hefitated to affert its being made for him alone. The diftribution of land and water *, fay they, is admirable; the one being laid againft the other fo fkilfully, that there is a juft equipoife of the whole globe. Thus the Northern Ocean balances againft the Southern; and the New Continent is an exact counter-weight to the Old. As to any objection from the ocean's occupying too large a fhare of

* Derham Phyfico-Theol.

the globe, they contend, that there could not have been a ſmaller ſurface employed to ſupply the earth with a due ſhare of evaporation. On the other hand, ſome take the gloomy ſide of the queſtion; they either magnify * its apparent defects; or aſſert, that † what ſeems defects to us, may be real beauties to ſome wiſer order of beings. They obſerve, that multitudes of animals are concealed in the ocean, and but a ſmall part of them are known; the reſt, therefore, they fail not to ſay, were certainly made for their own benefit, and not for ours. How far either of theſe opinions be juſt, I will not preſume to determine; but of this we are certain, that God has endowed us with abilities to turn this great extent of waters to our own advantage. He has made theſe things, perhaps, for other uſes; but he has given us faculties to convert them to our own. This much agitated queſtion, therefore, ſeems to terminate here. We ſhall never know whether the things of this world have been made for our uſe; but we very well know that we have been made to enjoy them. Let us then boldly affirm, that the earth, and all its wonders, are ours; ſince we are furniſhed with powers to force them into

* Burnet's Theory, paſſim. † Pope's Ethic Epiſtles, paſſim.

our service. Man is the lord of all the sublunary creation; the howling savage, the winding serpent, with all the untameable and rebellious offspring of Nature, are destroyed in the contest, or driven at a distance from his habitations. The extensive and tempestuous ocean, instead of limiting or dividing his power, only serves to assist his industry, and enlarge the sphere of his enjoyments. Its billows, and its monsters, instead of presenting a scene of terror, only call up the courage of this little intrepid being; and the greatest danger that man now fears on the deep, is from his fellow-creatures. Indeed, when I consider the human race as Nature has formed them, there is but very little of the habitable globe that seems made for them. But when I consider them as accumulating the experience of ages, in commanding the earth, there is nothing so great, or so terrible. What a poor contemptible being is the naked savage, standing on the beach of the ocean, and trembling at its tumults! How little capable is he of converting its terrors into benefits; or of saying, behold an element made wholly for my enjoyment! He considers it as an angry deity, and pays it the homage of submission. But it is very different when he has exercised his mental

powers; when he has learned to find his own ſuperiority, and to make it ſubſervient to his commands. It is then that his dignity begins to appear, and that the true Deity is juſtly praiſed for having been mindful of man; for having given him the earth for his habitation, and the ſea for an inheritance.

This power which man has obtained over the ocean, was at firſt enjoyed in common; and none pretended to a right in that element where all ſeemed intruders. The ſea, therefore, was open to all till the time of the emperor Juſtinian. His ſucceſſor Leo granted ſuch as were in poſſeſſion of the ſhore, the ſole right of fiſhing before their reſpective territories. The Thracian Boſphorus was the firſt that was thus appropriated; and from that time it has been the ſtruggle of moſt of the powers of Europe to obtain an excluſive right in this element. The Republic of Venice claims the Adriatic. The Danes are in poſſeſſion of the Baltic. But the Engliſh have a more extenſive claim to the empire of all the ſeas, encompaſſing the kingdoms of England, Scotland, and Ireland; and although theſe have been long conteſted, yet they are now conſidered as their indiſputable property. Every one knows that the great power

of the nation is exerted on this element; and that the instant England ceases to be superior upon the ocean, its safety begins to be precarious.

It is in some measure owing to our dependance upon the sea, and to our commerce there, that we are so well acquainted with its extent and figure. The bays, gulphs, currents, and shallows of the ocean, are much better known and examined than the provinces and kingdoms of the earth itself. The hopes of acquiring wealth by commerce, has carried man to much greater length than the desire of gaining information could have done. In consequence of this, there is scarce a strait or an harbour, scarce a rock or a quicksand, scarce an inflexion of the shore, or the jutting of a promontory, that has not been minutely described. But as these present very little entertainment to the imagination, or delight to any but those whose pursuits are lucrative, they need not be dwelt upon here. While the merchant and the mariner are solicitous in describing current and soundings, the naturalist is employed in observing wonders, though not so beneficial, yet to him of a much more important nature. The saltness of the sea seems to be foremost.

Whence the sea has derived that peculiar bitterish saltness which we find in it, appears, by

Ariſtotle, to have exerciſed the curioſity of naturaliſts in all ages. He ſuppoſed (and mankind were for ages content with the ſolution) that the ſun continually raiſed dry ſaline exhalations from the earth, and depoſited them upon the ſea; and hence, ſay his followers, the waters of the ſea are more ſalt at top than at bottom. But, unfortunately for this opinion, neither of the facts is true. Sea ſalt is not to be raiſed by the vapours of the ſun; and ſea water is not ſalter at the top than at the bottom. Father Bohours is of opinion that the Creator gave the waters of the ocean their ſaltneſs at the beginning; not only to prevent their corruption, but to enable them to bear greater burthens. But their ſaltneſs does not prevent their corruption; for ſtagnant ſea-water, like freſh, ſoon grows putrid: and, as for their bearing greater burthens, freſh water anſwers all the purpoſes of navigation quite as well. The eſtabliſhed opinion, therefore, is that of Boyle*, who ſuppoſes, "that the ſea's ſaltneſs is ſupplied not only from rocks or maſſes of ſalt at the bottom of the ſea, but alſo from the ſalt which the rains and rivers, and other waters, diſſolve in their paſſage through many parts of the earth, and at length carry with them to the ſea." But as there is a differ-

* Boyle, vol. iii. p. 221.

ence in the taſte of rock-ſalt found at land, and that diſſolved in the waters of the ocean, this may be produced by the plenty of nitrous and bituminous bodies that, with the ſalts, are likewiſe waſhed into that great receptacle. Theſe ſubſtances being thus once carried to the ſea, muſt for ever remain there; for they do not riſe by evaporation, ſo as to be returned back from whence they came. Nothing but the freſh waters of the ſea riſe in vapours; and all the ſaltneſs remains behind. From hence it follows, that every year the ſea muſt become more and more ſalt; and this ſpeculation Doctor Halley carries ſo far as to lay down a method of finding out the age of the world by the ſaltneſs of its waters. "For if it be obſerved*," ſays he, "what quantity of ſalt is at preſent contained in a certain weight of water, taken up from the Caſpian Sea, for example, and, after ſome centuries, what greater quantity of ſalt is contained in the ſame weight of water, taken from the ſame place; we may conclude, that in proportion as the ſaltneſs has encreaſed in a certain time, ſo much muſt it have encreaſed before that time; and we may thus, by the rule of proportion, make an eſtimate of the whole time wherein the water would acquire the degree

* Phil. Tranſ. vol. v. p. 218.

of faltnefs it fhould be then poffeffed of." All this may be fine; however, an experiment, begun in this century, which is not to be completed till fome centuries hence, is rather a little mortifying to modern curiofity: and, I am induced to think, the inhabitants round the Cafpian Sea, will not be apt to undertake the enquiry.

This faltnefs is found to prevail in every part of the ocean; and as much at the furface as at the bottom. It is alfo found in all thofe feas that communicate with the ocean; but rather in a lefs degree.

The great lakes, likewife, that have no outlets nor communication with the ocean, are found to be falt: but fome of them in lefs proportion. On the contrary, all thofe lakes through which rivers run into the fea, however extenfive they be, are, notwithftanding, very frefh: for the rivers do not depofit their falts in the bed of the lake, but carry them, with their currents, into the ocean. Thus the lakes Ontario and Erie, in North America, although for magnitude they may be confidered as inland feas, are, neverthelefs, frefh water lakes; and kept fo by the river St. Lawrence, which paffes through them. But thofe lakes that have no communication with the fea, nor any rivers going out, although they be lefs than the

former, are, however, always ſalt. Thus, that which goes by the name of the Dead Sea, though very ſmall, when compared to thoſe already mentioned, is ſo exceedingly ſalt, that its waters ſeem ſcarce capable of diſſolving any more. The lakes of Mexico, and of Titicaca, in Peru, though of no great extent, are, nevertheleſs, ſalt; and both for the ſame reaſon.

Thoſe who are willing to turn all things to the beſt, have not failed to conſider this ſaltneſs of the ſea, as a peculiar bleſſing from Providence, in order to keep ſo great an element ſweet and wholſome. What foundation there may be in the remark, I will not pretend to determine; but we ſhall ſhortly find a much better cauſe for its being kept ſweet, namely, its motion.

On the other hand, there have been many who have conſidered the ſubject in a different light, and have tried every endeavour to make ſalt-water freſh, ſo as to ſupply the wants of mariners in long voyages, or when exhauſted of their ordinary ſtores. At firſt it was ſuppoſed ſimple diſtillation would do; but it was ſoon found that the bitter part of the water ſtill kept mixed. It was then tried by uniting ſalt of Tartar with ſea-water, and diſtilling both: but here the expence was greater than the advantage. Calcined bones were next thought

of; but an hogſhead of calcined bones, carried to ſea, would take up as much room as an hogſhead of water, and was more hard to be obtained. In this ſtate, therefore, have the attempts to ſweeten ſea-water reſted; the chymiſt ſatisfied with the reality of his invention; and the mariner convinced of its being uſeleſs. I cannot, therefore, avoid mentioning a kind of ſuccedaneum which has been lately conceived to anſwer the purpoſes of freſh-water, when mariners are quite exhauſted. It is well known, the perſons who go into a warm bath, come out ſeveral ounces heavier than they went in; their bodies having imbibed a correſpondent quantity of water. This more particularly happens, if they have been previouſly debarred from drinking, or go in with a violent thirſt; which they quickly find quenched, and their ſpirits reſtored. It was ſuppoſed, that in caſe of a total failure of freſh-water at ſea, a warm bath might be made of ſea-water, for the uſe of mariners; and that their pores would thus imbibe the fluid, without any of its ſalts, which would be ſeen to cryſtallize on the ſurface of their bodies. In this manner, it is ſuppoſed, a ſufficient quantity of moiſture may be procured to ſuſtain life, till time or accident furniſh a more copious ſupply.

But, however this be, the ſaltneſs of the ſea

can by no means be considered as a principal cause in preserving its waters from putrefaction. The ocean has its currents, like rivers, which circulate its contents round the globe; and these may be said to be the great agents that keep it sweet and wholsome. Its saltness alone would by no means answer this purpose: and some have even imagined, that the various substances with which it is mixed, rather tend to promote putresence than impede it. Sir Robert Hawkins, one of our most enlightened navigators, gives the following account of a calm, in which the sea continuing for some time without motion, began to assume a very formidable appearance. "Were it not," says he, "for the moving of the sea, by the force of winds, tides, and currents, it would corrupt all the world. The experiment of this I saw in the year 1590, lying with a fleet about the islands of Azores, almost six months; the greatest part of which time we were becalmed. Upon which all the sea became so replenished with several sorts of jellies, and forms of serpents, adders, and snakes, as seemed wonderful: some green, some black, some yellow, some white, some of divers colours, and many of them had life; and some there were an yard and an half, and two yards long; which had I not seen, I could hardly have

believed. And hereof are witnesses all the company of the ships which were then present: so that hardly a man could draw a bucket of water clear of some corruption. In which voyage, towards the end thereof, many of every ship fell sick, and began to die apace. But the speedy passage into our country, was a remedy to the crazed, and a preservative for those that were not touched."

This shews, abundantly, how little the sea's saltness was capable of preserving it from putrefaction: but, to put the matter beyond all doubt, Mr. Boyle kept a quantity of sea-water, taken up in the English channel, for some time barrelled up; and, in the space of a few weeks, it began to acquire a fœtid smell*: he was also assured, by one of his acquaintance who was becalmed for twelve or fourteen days in the Indian sea, that the water, for want of motion, began to stink; and that had it continued much longer, the stench would probably have poisoned him. It is the motion, therefore, and not the saltness of the sea, that preserves it in its present state of salubrity; and this, very probably, by dashing and breaking in pieces the rudiments, if I may so call them, of the various animals that would otherwise breed there, and putrefy

* Boyle, vol. iii. p. 222.

There are ſome advantages, however, which are derived from the ſaltneſs of the ſea. Its waters being evaporated, furniſh that ſalt which is uſed for domeſtic purpoſes; and, although in ſome places it is made from ſprings, and, in others, dug out of mines, yet the greateſt quantity is made only from the ſea. That which is called bay-ſalt, (from its coming to us by the Bay of Biſcay) is a ſtronger kind, made by evaporation in the ſun: that called common ſalt, is evaporated in pans over the fire, and is of a much inferior quality to the former.

Another benefit ariſing from the quantity of ſalt diſſolved in the ſea, is, that it thus becomes heavier, and, conſequently, more buoyant. Mr. Boyle, who examined the difference between ſea-water and freſh, found that the former appeared to be about a forty-fifth part heavier than the latter. Thoſe, alſo, who have had opportunities of bathing in the ſea, pretend to have experienced a much greater eaſe in ſwimming there, than in freſh water. However, as we ſee they have only a forty-fifth part more of their weight ſuſtained by it, I am apt to doubt whether ſo minute a difference can be practically perceivable. Be this as it may, as ſea-water alters in its weight from freſh, ſo it is found alſo to differ from itſelf in different parts of the ocean.

In general, it is perceived to be heavier, and, consequently, salter, the nearer we approach the Line *.

But there is an advantage arising from the saltness of the waters of the sea, much greater than what has been yet mentioned; which is, that their congelation is thus retarded. Some, indeed, have gone so far as to say, that † sea-water never freezes: but this is an assertion contradicted by experience. However, it is certain that it requires a much greater degree of cold to freeze it than fresh water; so that, while rivers and springs are seen converted into one solid body of ice, the sea is always fit for navigation, and no way affected by the coldness of the severest winter. It is, therefore, one of the greatest blessings we derive from this element, that when at land all the stores of Nature are locked up from us, we find the sea ever open to our necessities, and patient of the hand of industry.

But it must not be supposed, because in our temperate climate we never see the sea frozen, that it is in the same manner open in every part of it. A very little acquaintance with the accounts of mariners, must have informed us, that at the polar regions it is embarrassed with moun-

* Phil. Transf. vol. ii. p. 297. † Macrobius.

tains, and moving ſheets of ice, that often render it impaſſable. Theſe tremendous floats are of different magnitudes; ſometimes riſing more than a thouſand feet above the ſurface of the water *; ſometimes diffuſed into plains of above two hundred leagues in length; and, in many parts, ſixty or eighty broad. They are uſually divided by fiſſures; one piece following another ſo cloſe, that a perſon may ſtep from one to the other. Sometimes mountains are ſeen riſing amidſt theſe plains, and preſenting the appearance of a variegated landſcape, with hills and valleys, houſes, churches, and towers. Theſe are appearances in which all naturaliſts are agreed; but the great conteſt is reſpecting their formation. Mr. Buffon aſſerts †, that they are formed from freſh water alone; which congealing at the mouths of great rivers, accumulate thoſe huge maſſes that diſturb navigation. However, this great naturaliſt ſeems not to have been aware that there are two ſorts of ice floating in theſe ſeas; the flat ice, and the mountain ice: the one formed of ſea-water only; the other, of freſh ‡.

The flat, or driving ice, is entirely compoſed

* Krantz's Hiſtory of Greenland, vol. i. p. 31.

† Buffon, vol. ii. p. 91. ‡ Krantz.

of sea-water; which, upon dissolution, is found to be salt; and is readily distinguished from the mountain or fresh-water ice, by its whiteness, and want of transparency. This ice is much more terrible to mariners than that which rises up in lumps: a ship can avoid the one, as it is seen at a distance; but it often gets in among the other, which sometimes closing, crushes it to pieces. This, which manifestly has a different origin from the fresh-water ice, may perhaps have been produced in the Icy Sea, beneath the Pole; or along the coasts of Spitzberg, or Nova Zembla.

The mountain-ice, as was said, is different in every respect, being formed of fresh water, and appearing hard and transparent; it is generally of a pale green colour, though some pieces are of a beautiful sky blue; many large masses, also, appear grey; and some black. If examined more nearly, they are found to be incorporated with earth, stones, and brush-wood washed from the shore. On these also are sometimes found, not only earth, but nests with birds eggs, at several hundred miles from land. The generality of these, though almost totally fresh, have, nevertheless, a thick crust of salt-water frozen upon them, probably from the power that ice has sometimes to produce ice.

Such mountains as are here defcribed, are moft ufually feen at fpring-time, and after a violent ftorm, driving out to fea, where they at firft terrify the mariner, and are foon after dafhed to pieces by the continual wafhing of the waves; or driven into the warmer regions of the fouth, there to be melted away. They fometimes, however, ftrike back upon their native fhores, where they feem to take root at the feet of mountains; and, as Martius tells us, are fometimes higher than the mountains themfelves. Thofe feen by him were blue, full of clefts and cavities made by the rain, and crowned with fnow, which alternately thawing and freezing every year, augmented their fize. Thefe, compofed of materials more folid than that driving at fea, prefented a variety of agreeable figures to the eye, that, with a little help from fancy, affumed the appearance of trees in bloffom; the infide of churches, with arches, pillars, and windows; and the blue coloured rays, darting from within, prefented the refemblance of a glory.

If we enquire into the origin and formation of thefe, which, as we fee, are very different from the former, I think we have a very fatisfactory account of them in Krantz's Hiftory

of Greenland; and I will take leave to give the paſſage, with a very few alterations. "Theſe mountains of ice," ſays he, "are not ſalt, like the ſea-water, but ſweet; and, therefore, can be formed no where except on the mountains, in rivers, in caverns, and againſt the hills near the ſea-ſhore. The mountains of Greenland are ſo high, that the ſnow which falls upon them, particularly on the north ſide, is, in one night's time, wholly converted into ice: they alſo contain clefts and cavities, where the ſun ſeldom or never injects his rays: beſides theſe, are projections, or landing-places, on the declivities of the ſteepeſt hills, where the rain and ſnow-water lodge, and quickly congeal. When now the accumulated flakes of ſnow ſlide down, or fall with the rain from the eminences above, on theſe prominences; or, when here and there a mountain-ſpring comes rolling down to ſuch a lodging place, where the ice has already ſeated itſelf, they all freeze, and add their tribute to it. This, by degrees, waxes to a body of ice, that can no more be overpowered by the ſun; and which, though it may indeed, at certain ſeaſons, diminiſh by a thaw, yet, upon the whole, through annual acquiſitions, it aſſumes an annual growth. Such a body of ice is often prominent far over

the rocks. It does not melt on the upper ſurface, but underneath; and often cracks into many larger or ſmaller clefts, from whence the thawed water trickles out. By this it becomes, at laſt, ſo weak, that being overloaded with its own ponderous bulk, it breaks looſe, and tumbles down the rocks with a terrible craſh. Where it happens to overhang a precipice on the ſhore, it plunges into the deep with a ſhock like thunder; and with ſuch an agitation of the water, as will overſet a boat at ſome diſtance, as many a poor Greenlander has fatally experienced." Thus are theſe amazing ice mountains launched forth to ſea, and found floating in the waters round both the Poles. It is theſe that have hindered mariners from diſcovering the extenſive countries that lie round the South Pole; and that probably block up the paſſage to China by the North.

I will conclude this chapter with one effect more, produced by the ſaltneſs of the ſea; which is, the luminous appearance of its waves in the night. All who have been ſpectators of a ſea by night, a little ruffled with winds, ſeldom fail of obſerving its fiery brightneſs. In * ſome places it ſhines as far as the eye can reach;

* Boyle, vol. i. p. 294.

at other times, only when the waves boom againſt the ſide of the veſſel, or the oar daſhes into the water. Some ſeas ſhine often; others more ſeldom; ſome, ever when particular winds blow; and others, within a narrow compaſs; a long tract of light being ſeen along the ſurface, whilſt all the reſt is hid in total darkneſs. It is not eaſy to account for theſe extraordinary appearances: ſome have ſuppoſed that a number of luminous inſects produced the effect, and this is in reality ſometimes the caſe; in general, however, they have every reſemblance to that light produced by electricity; and, probably, ariſe from the agitation and daſhing of the ſaline particles of the fluid againſt each other. But the manner in which this is done, for we can produce nothing ſimilar by any experiments hitherto made, remains for ſome happier accident to diſcover. Our progreſs in the knowledge of nature is ſlow; and it is a mortifying conſideration, that we are hitherto more indebted for ſucceſs to chance than induſtry.

CHAP. XVI.

Of the Tides, Motion, and Currents of the Sea; with their Effects.

IT was ſaid, in the former chapter, that the waters of the ſea were kept ſweet by their motion; without which they would ſoon putrefy, and ſpread univerſal infection. If we look for final cauſes, here, indeed, we have a great and an obvious one that preſents itſelf before us. Had the ſea been made without motion, and reſembling a pool of ſtagnant water, the nobler races of animated nature would ſhortly be at an end. Nothing would then be left alive but ſwarms of ill-formed creatures, with ſcarce more than vegetable life; and ſubſiſting by putrefaction. Were this extenſive bed of waters entirely quieſcent, millions of the ſmaller reptile kinds would there find a proper retreat to breed and multiply in; they would find there no agitation, no concuſſion in the parts of the fluid to cruſh their feeble frames, or to force them from the places where they were bred: there they would multiply in ſecurity and eaſe, enjoy a ſhort life, and putrefying, thus again give nouriſhment to numberleſs others, as little

worthy of exiſtence as themſelves. But the motion of this great element effectually deſtroys the number of theſe viler creatures; its currents and its tides produce continual agitations, the ſhock of which they are not able to endure; the parts of the fluid rub againſt each other, deſtroy all viſcidities; and the ocean, if I may ſo expreſs it, acquires health by exerciſe.

The moſt obvious motion of the ſea, and the moſt generally acknowledged, is that of its tides. This element is obſerved to flow for certain hours, from ſouth towards the north; in which motion or flux, which laſts about ſix hours, the ſea gradually ſwells; ſo that entering the mouths of rivers, it drives back the river waters to their heads. After a continual flux of ſix hours, the ſea ſeems to reſt for a quarter of an hour; and then begins to ebb, or retire back again, from north to ſouth, for ſix hours more; in which time the waters ſinking, the rivers reſume their natual courſe. After a ſeeming pauſe of a quarter of an hour, the ſea again begins to flow as before: and thus it has alternately riſen and fallen, twice a day, ſince the creation.

This amazing appearance did not fail to excite the curioſity, as it did the wonder of the ancients. After ſome wild conjectures of the

earlieſt philoſophers, it became well known, in the times of Pliny, that the tides were entirely under the influence, in a ſmall degree, of the ſun; but in a much greater of the moon. It was found that there was a flux and reflux of the ſea, in the ſpace of twelve hours fifty minutes, which is exactly the time of a lunar day. It was obſerved, that whenever the moon was in the meridian, or, in other words, as nearly as poſſible over any part of the ſea, that the ſea flowed to that part, and made a tide there; on the contrary, it was found, that when the moon left the meridian, the ſea began to flow back again from whence it came; and there might be ſaid to ebb. Thus far the waters of the ſea ſeemed very regularly to attend the motions of the moon. But as it appeared, likewiſe, that when the moon was in the oppoſite meridian, as far off on the other ſide of the globe, that there was a tide on this ſide alſo; ſo that the moon produced two tides, one by her greateſt approach to us, and another by her greateſt diſtance from us: in other words, the moon, in once going round the earth, produced two tides, always at the ſame time; one on the part of the globe directly under her; and the other, on the part of the globe directly oppoſite.

Mankind continued for ſeveral ages content with knowing the general cauſe of theſe wonders, hopeleſs of diſcovering the particular manner of the moon's operation. Kepler was the firſt who conjectured that attraction was the principal cauſe; aſſerting, that the ſphere of the moon's operation extended to the earth, and drew up its waters. The preciſe manner in which this is done, was diſcovered by Newton.

The moon has been found, like all the reſt of the planets, to attract, and to be attracted by the earth. This attraction prevails throughout our whole planetary ſyſtem. The more matter there is contained in any body, the more it attracts: and its influence decreaſes in proportion as the diſtance, when ſquared, encreaſes. This being premiſed, let us ſee what muſt enſue upon ſuppoſing the moon in the meridian of any tract of the ſea. The ſurface of the water immediately under the moon, is nearer the moon than any other part of the globe is; and, therefore, muſt be more ſubject to its attraction than the waters any where elſe. The waters will, therefore, be attracted by the moon, and riſe in an heap; whoſe eminence will be the higheſt where the attraction is greateſt. In order to form this eminence, it is obvious that

the ſurface, as well as the depths, will be agitated; and that wherever the water runs from one part, ſucceeding waters muſt run to fill up the ſpace it has left. Thus the waters of the ſea, running from all parts, to attend the motions of the moon, produce the flowing of the tide; and it is high tide at that part wherever the moon comes over it, or to its meridian.

But when the moon travels onward, and ceaſes to point over the place where the waters were juſt riſen, the cauſe here of their riſing ceaſing to operate, they will flow back by their natural gravity, into the lower parts from whence they had travelled; and this retiring of the waters will form the ebbing of the ſea.

Thus the firſt part of the demonſtration is obvious; ſince, in general, it requires no great ſagacity to conceive that the waters neareſt the moon are moſt attracted, or raiſed higheſt by the moon. But the other part of the demonſtration, namely, how there come to be high tides at the ſame time, on the oppoſite ſide of the globe, and where the waters are fartheſt from the moon, is not ſo eaſy to conceive. To comprehend this, it muſt be obſerved, that the part of the earth, and its waters, that are fartheſt from the moon, are the parts of all others that

are leaſt attracted by the moon: it muſt alſo be obſerved, that all the waters, when the moon is on the oppoſite ſide of the earth, muſt be attracted by it in the ſame direction that the earth itſelf attracts them; that is, if I may ſo ſay, quite through the body of the earth, towards the moon itſelf. This, therefore, being conceived, it is plain that thoſe waters which are fartheſt from the moon, will have leſs weight than thoſe of any other part, on the ſame ſide of the globe; becauſe the moon's attraction, which conſpires with the earth's attraction, is there leaſt. Now, therefore, the waters fartheſt from the moon, having leſs weight, and being lighteſt, will be preſſed on all ſides, by thoſe that, having more attraction, are heavier: they will be preſſed, I ſay, on all ſides; and the heavier waters flowing in, will make them ſwell and riſe in an eminence directly oppoſite to that on the other ſide of the globe, cauſed by the more immediate influence of the moon.

In this manner the moon, in one diurnal revolution, produces two tides; one raiſed immediately under the ſphere of its influence, and the other directly oppoſite to it. As the moon travels, this vaſt body of waters rears upward, as if to watch its motions; and purſues the ſame conſtant rotation. However, in this great work

of raiſing the tides, the ſun has no ſmall ſhare; it produces its own tides conſtantly every day, juſt as the moon does, but in a much leſs degree, becauſe the ſun is at an immenſely greater diſtance. Thus there are ſolar tides, and lunar tides. When the forces of theſe two great luminaries concur, which they always do when they are either in the ſame, or in oppoſite parts of the heavens, they jointly produce a much greater tide, than when they are ſo ſituated in the heavens, as each to make peculiar tides of their own. To expreſs the very ſame thing technically; in the conjunctions and oppoſitions of the ſun and moon, the attraction of the ſun conſpires with the attraction of the moon; by which means the high ſpring-tides are formed. But in the quadratures of the ſun and moon, the water raiſed by the one is depreſſed by the other; and hence the lower neap-tides have their production. In a word, the tides are greateſt in the ſyzigies, and leaſt in the quadratures.

This theory well underſtood, and the aſtronomical terms previouſly known, it may readily be brought to explain the various appearances of the tides, if the earth were covered with a deep ſea, and the waters uninfluenced by ſhoals, currents, ſtraits, or tempeſts. But in every part of the ſea, near the ſhores, the geographer

muſt come in to correct the calculations of the aſtronomer. For, by reaſon of the ſhallowneſs of ſome places, and the narrowneſs of the ſtraits in others, there ariſes a great diverſity in the effect, not to be accounted for without an exact knowledge of all the circumſtances of the place. In the great depths of the ocean, for inſtance, a very ſlow and imperceptible motion of the whole body of water will ſuffice to raiſe its ſurface ſeveral feet high; but if the ſame encreaſe of water is to be conveyed through a narrow channel, it muſt ruſh through it with the moſt impetuous rapidity. Thus in the Engliſh channel, and the German ocean, the tide is found to flow ſtrongeſt in thoſe places that are narroweſt; the ſame quantity of water being, in this caſe, driven through a ſmaller paſſage. It is often ſeen, therefore, pouring through a ſtreight with great force; and, by its rapidity, conſiderably raiſed above the ſurface of that part of the ocean into which it runs.

This ſhallowneſs and narrowneſs in many parts of the ſea, give alſo riſe to a peculiarity in the tides of ſome parts of the world. For in many places, and in our own ſeas in particular, the greateſt ſwell of the tide is not while the moon is in its meridian height, and directly over the place, but ſome time after it

has declined from thence. The ſea, in this caſe, being obſtructed, purſues the moon with what diſpatch it can, but does not arrive with all its waters till long after the moon has ceaſed to operate. Laſtly, from this ſhallowneſs of the ſea, and from its being obſtructed by ſhoals and ſtreights, we may account for the Mediterranean, the Baltic, and the Black Sea, having no ſenſible tides. Theſe, though to us they ſeem very extenſive, are not however large enough to be affected by the influence of the moon; and as to their communication with the ocean, through ſuch narrow inlets, it is impoſſible in a few hours they ſhould receive and return water enough to raiſe or depreſs them in any conſiderable degree.

In general we may obſerve, that all tides are much higher, and more conſiderable in the torrid zone, than in the reſt of the ocean; the ſea in thoſe parts being generally deeper, and leſs affected by changeable winds, or winding ſhores *. The greateſt tide we know of, is that at the mouth of the river Indus, where the water riſes thirty feet in height. How great, therefore, muſt have been the amazement of Alexander's ſoldiers at ſo ſtrange an appearance! They who always before had been accuſtomed

* Buffon, vol. ii. p. 187.

only to the fcarcely perceptible rifings of the Mediterranean, or the minute intumefcence of the Black Sea, when made at once fpectators of a river rifing and falling thirty feet in a few hours, muft no doubt have felt the moft extreme awe, and, as we are told *, a mixture of curiofity and apprehenfion. The tides are alfo remarkably high on the coafts of Malay, in the ftreights of Sunda, in the Red Sea, at the mouth of the river St. Lawrence, along the coafts of China and Japan, at Panama, and in the gulph of Bengal. The tides at Tonquin, however, are the moft remarkable in the world. In this part there is but one tide, and one ebb, in twenty-four hours; whereas, as we have faid before, in other places there are two. Befides, there, twice in each month there is no tide at all, when the moon is near the equinoctial, the water being for fome time quite ftagnant. Thefe, with fome other odd appearances attending the fame phænomena, were confidered by many as infcrutable; but Sir Ifaac Newton, with peculiar fagacity, adjudged them to arife from the concurrence of two tides, one from the South Sea, and the other from the Indian Ocean. Of each of thefe tides there come fucceffively two every day; two at one time greater, and two at another

* Quintus Curtius.

that are lefs. The time between the arrival of the two greater, is confidered by him as high tide; the time between the two leffer, as ebb. In fhort, with this clue, that great mathematician folved every appearance, and fo eftablifhed his theory as to filence every oppofer.

This fluctuation of the fea from the tides, produces another, and more conftant rotation of its waters, from the eaft to the weft, in this refpect following the courfe of the moon. This may be confidered as one great and general current of the waters of the fea; and although it be not every where diftinguifhable, it is neverthelefs every where exiftent, except when oppofed by fome particular current or eddy, produced by partial and local caufes. This tendency of the fea towards the weft, is plainly perceivable in all the great ftreights of the ocean; as, for inftance, in thofe of Magellan, where the tide running in from the eaft, rifes twenty feet high, and continues flowing fix hours; whereas the ebb continues but two hours, and the current is directed to the weft. This proves that the flux is not equal to the reflux; and that from both refults a motion of the fea weftward, which is more powerful during the time of the flux than the reflux.

But this motion weftward has been fenfibly

observed by navigators, in their passage back from India to Madagascar, and so on to Africa. In the great Pacific Ocean also it is very perceivable: but the places where it is most obvious are, as was said, in those streights which join one ocean to another. In the streights between the Maldivia islands, in the gulph of Mexico, between Cuba and Jucatan. In the streights of the gulph of Paria, the motion is so violent, that it hath received the appellation of the Dragon's Mouth. Northward, in the sea of Canada, in Waigat's streights, in the streights of Java, and, in short, in every streight where the ocean on one part pours into the ocean on the other. In this manner, therefore, is the sea carried with an unceasing circulation round the globe; and, at the same time that its waters are pushed back and forward with the tide, they have thus a progressive current to the west, which, though less observable, is not the less real.

Besides these two general motions of the sea, there are others which are particular to many parts of it, and are called currents. These are found to run in all directions, east, west, north, and south; being formed, as was said above, by various causes; the prominence of the shores, the narrowness of the streights, the variations of

the wind, and the inequalities at the bottom. These, though no great object to the philosopher, as their causes are generally local and obvious, are neverthelesss of the most material consequence to the mariner; and, without a knowledge of which, he could never succeed. It often has happened, that when a ship has unknowingly got into one of these, every thing seems to go forward with success, the mariners suppose themselves every hour approaching their wish'd-for port, the wind fills their sails, and the ship's prow seems to divide the water; but, at last, by miserable experience they find, that instead of going forward, they have been all the time receding. The business of currents, therefore, makes a considerable article in navigation; and the direction of their stream, and their rapidity, has been carefully set down. This some do by the observation of the surface of the current; or by the driving of the froth along the shore; or by throwing out what is called the log-line, with a buoy made for that purpose: and by the direction and motion of this, they judge of the setting, and the rapidity of the current.

These currents are generally found to be most violent under the equator, where indeed all the motions of the ocean are most perceivable.

Along the coafts of Guinea, if a fhip happens to overfhoot the mouth of any river it is bound to, the current prevents its return; fo that it is obliged to fteer out to fea, and take a very large compafs, in order to correct the former miftake. Thefe fet in a contrary direction to the general motion of the fea weftward; and that fo ftrongly, that a paffage which with the current is made in two days, is with difficulty performed in fix weeks againft it. However, they do not extend above twenty leagues from the coaft; and fhips going to the Eaft-Indies, take care not to come within the fphere of their action. At Sumatra, the currents, which are extremely rapid, run from fouth to north: there are alfo ftrong currents between Madagafcar and the Cape of Good Hope. On the weftern coafts of America, the current always runs from the fouth to the north, where a fouth wind, continually blowing, moft probably occafions this phænomenon. But the currents that are moft remarkable, are thofe continually flowing into the Mediterranean fea, both from the ocean by the ftreights of Gibraltar, and at its other extremity, from the Euxine fea by the Archipelago. This is one of the moft extraordinary appearances in nature, this large fea receiving not only the numerous rivers that fall into it,

ſuch as the Nile, the Rhone, and the Po, but alſo a very great influx from the Euxine ſea on one part, and the ocean on the other. At the ſame time, it is ſeen to return none of thoſe waters it is thus known to receive: outlets running from it there are none; no rivers but ſuch as bring it freſh ſupplies; no ſtreights but what are conſtantly pouring their waters into it. It has therefore been the wonder of mankind in every age, how and by what means this vaſt concourſe of waters are diſpoſed of; or how this ſea, which is always receiving, and never returning, is no way fuller than before. In order to account for this, ſome have ſaid, that the water was re-conveyed by ſubterraneous paſſages into the Red Sea*. There is a ſtory told of an Arabian cailiff, who caught a dolphin in this ſea, admiring the beauty of which, he let it go again, having previouſly marked it by a ring of iron. Some time after a dolphin was caught in the Red Sea, and quickly known by the ring to be the ſame that had been taken in the Mediterranean before. Such, however, as have not been willing to found their opinions upon a ſtory, have attempted to account for the diſpoſal of the waters of the Mediterranean by evaporation. For this purpoſe they have entered into long calculations

* Kircher Mund. Subt. vol. i.

upon the extent of its ſurface, and the quantity of water that would be raiſed from ſuch a ſurface in a year. They then compute how much water runs in by its rivers and ſtreights in that time; and find, that the quantity exhauſted by evaporation greatly exceeds the quantity ſupplied by rivers and ſeas. This ſolution, no doubt, would be ſatisfactory, did not the ocean, and the Euxine, evaporate as well as the Mediterranean: and as theſe are ſubject to the ſame drain, it muſt follow, that all the ſeas will in this reſpect be upon a par; and, therefore, there muſt be ſome other cauſe for this unperceived drain, and continual ſupply. This ſeems to be ſatisfactorily enough accounted for by Doctor Smith, who ſuppoſes an under current running through the ſtreights of Gibraltar to carry out as much water into the ocean, as the upper current continually carries in from it. To confirm this, he obſerves, that nearer home, between the north and ſouth foreland, the tide is known to run one way at top, and the ebb another way at bottom. This double current he alſo confirms by an experiment communicated to him by an able ſeaman, who being with one of the king's frigates in the Baltic, found he went with his boat into the mid-ſtream, and was carried violently by the current; upon which a baſket was ſunk, with a large cannon-

ball, to a certain depth of water, which gave a check to the boat's motion; as the baſket ſunk ſtill lower, the boat was driven, by the force of the water below, againſt the upper current; and the lower the baſket was let down, the ſtronger the under current was found, and the quicker was the boat's motion againſt the upper ſtream, which ſeemed not to be above four fathom deep. From hence we may readily infer, that the ſame cauſe may operate at the ſtreights of Gibraltar; and that while the Mediterranean ſeems repleniſhing at top, it may be emptying at bottom.

The number of the currents at ſea are impoſſible to be recounted, nor indeed are they always known; new ones are daily produced by a variety of cauſes, and as quickly diſappear. When a regular current is oppoſed by another in a narrow ſtreight, or where the bottom of the ſea is very uneven, a whirlpool is often formed. Theſe were formerly conſidered as the moſt formidable obſtructions to navigation, and the ancient poets and hiſtorians ſpeak of them with terror; they are deſcribed as ſwallowing up ſhips, and daſhing them againſt the rocks at the bottom: apprehenſion did not fail to add imaginary terrors to the deſcription, and placed at the center of the whirlpool a dreadful den,

fraught with monſters whoſe howlings ſerved to add new horrors to the daſhings of the deep. Mankind at preſent, however, view theſe eddies of the ſea with very little apprehenſion; and ſome have wondered how the ancients could have ſo much overcharged their deſcriptions. But all this is very naturally accounted for. In thoſe times when navigation was in its infancy, and the ſlighteſt concuſſion of the waves generally ſent the poor adventurer to the bottom, it is not to be wondered at that he was terrified at the violent agitations in one of theſe. When his little ſhip, but ill fitted for oppoſing the fury of the ſea, was got within the vortex, there was then no poſſibility of ever returning. To add to the fatality, they were always near the ſhore; and along the ſhore was the only place where this ill provided mariner durſt venture to ſail. Theſe were, therefore, dreadful impediments to his navigation; for if he attempted to paſs between them and the ſhore, he was ſometimes ſucked in by the eddy; and if he attempted to avoid them out at ſea, he was often ſunk by the ſtorm. But in our time, and in our preſent improved ſtate of navigation, Charybdis, and the Euripus, with all the other irregular currents of the Mediterranean, are no longer formidable. Mr. Addiſon, not attending

to this train of thinking, upon paſſing through the ſtreights of Sicily, was ſurpriſed at the little there was of terror in the preſent appearance of Sylla and Charybdis; and ſeems to be of opinion, that their agitations are much diminiſhed ſince the times of antiquity. In fact, from the reaſons above, all the wonders of the Mediterranean ſea are deſcribed in much higher colours than they merit, to us who are acquainted with the more magnificent terrors of the ocean. The Mediterranean is one of the ſmootheſt and moſt gentle ſeas in the world; its tides are ſcarce perceivable, except in the gulph of Venice, and ſhipwrecks are leſs known there than in any other part of the world.

It is in the ocean, therefore, that theſe whirlpools are particularly dangerous, where the tides are violent, and the tempeſts fierce. To mention only one, that called the Maelſtroom, upon the coaſts of Norway, which is conſidered as the moſt dreadful and voracious in the world. The name it has received from the natives, ſignifies the navel of the ſea, ſince they ſuppoſe that a great ſhare of the water of the ſea is ſucked up and diſcharged by its vortex. A minute deſcription of the internal parts is not to be expected, ſince none who were there ever returned to bring back information. The body

of the waters that form this whirlpool, are extended in a circle above thirteen miles in circumference*. In the midſt of this ſtands a rock, againſt which the tide in its ebb is daſhed with inconceivable fury. At this time it inſtantly ſwallows up all things that come within the ſphere of its violence, trees, timber, and ſhipping. No ſkill in the mariner, nor ſtrength of rowing, can work an eſcape: the ſailor at the helm finds the ſhip at firſt go in a current oppoſite to his intentions; his veſſel's motion, though ſlow in the beginning, becomes every moment more rapid; it grows round in circles ſtill narrower and narrower, till at laſt it is daſhed againſt the rocks, and inſtantly diſappears: nor is it ſeen again for ſix hours: till the tide flowing, it is vomited forth with the ſame violence with which it was drawn in. The noiſe of this dreadful vortex ſtill farther contributes to encreaſe its terror, which with the daſhing of the waters, and the dreadful valley, if it may be ſo called, cauſed by their circulation, makes one of the moſt tremendous objects in nature.

* Kircher Mund. Subt. vol. i. p. 156.

CHAP.

CHAP. XVII.

Of the Changes produced by the Sea upon the Earth.

FROM what has been faid, as well of the earth as of the fea, they both appear to be in continual fluctuation. The earth, the common promptuary that fupplies fubfiftence to men, animals, and vegetables, is continually furnifhing its ftores to their fupport. But the matter which is thus derived from it, is foon reftored, and laid down again to be prepared for frefh mutations. The tranfmigration of fouls is no doubt falfe and whimfical; but nothing can be more certain than the tranfmigration of bodies: the fpoils of the meaneft reptile may go to the formation of a prince; and, on the contrary, as the poet has it, the body of Cæfar may be employed in ftopping a beer-barrel. From this, and other caufes, therefore, the earth is in continual change. Its internal fires, the deviation of its rivers, and the falling of its mountains, are daily altering its furface; and geography can fcarce recollect the lakes and the vallies that hiftory once defcribed.

But thefe changes are nothing to the infta-

bility of the ocean. It would ſeem that inquietude was as natural to it as its fluidity. It is firſt ſeen with a conſtant and equable motion going towards the weſt; the tides then interrupt this progreſſion, and for a time drive the waters in a contrary direction; beſide theſe agitations, the currents act their part in a ſmaller ſphere, being generally greateſt where the other motions of the ſea are leaſt; namely, neareſt the ſhore: the winds alſo contribute their ſhare in this univerſal fluctuation; ſo that ſcarce any part of the ſea is wholly ſeen to ſtagnate.

Nil enim quieſcit, undis impellitur unda,
Et ſpiritus et calor toto ſe corpore miſcent.

As this great element is thus changed, and continually labouring internally, it may be readily ſuppoſed that it produces correſpondent changes upon its ſhores, and thoſe parts of the earth ſubject to its influence. In fact, it is every day making conſiderable alterations, either by overflowing its ſhores in one place, or deſerting them in others; by covering over whole tracts of country, that were cultivated and peopled, at one time; or by leaving its bed to be appropriated to the purpoſes of vegetation, and to ſupply a new theatre for human induſtry at another.

In this ſtruggle between the earth and the ſea for dominion, the greateſt number of our ſhores ſeem to defy the whole rage of the waves, both by their height, and the rocky materials of which they are compoſed. The coaſts of Italy, for inſtance, *, are bordered with rocks of marble of different kinds, the quarries of which may eaſily be diſtinguiſhed at a diſtance from ſea, and appear like perpendicular columns, of the moſt beautiful kinds of marble, ranged along the ſhore. In general, the coaſts of France, from Breſt to Bourdeaux, are compoſed of rocks; as are alſo thoſe of Spain and England, which defend the land, and only are interrupted, here and there, to give an egreſs to rivers, and to grant the conveniencies of bays and harbours to our ſhipping. It may be in general remarked, that wherever the ſea is moſt violent and furious, there the boldeſt ſhores, and of the moſt compact materials, are found to oppoſe it. There are many ſhores ſeveral hundred feet perpendicular, againſt which the ſea, when ſwollen with tides or ſtorms, riſes and beats with inconceivable fury. In † the Orkneys, where the ſhores are thus formed, it ſometimes, when agitated by a ſtorm, riſes two hundred feet perpendicular, and daſhes up its ſpray,

* Buffon, vol. ii. p. 159. † Idem, vol. ii. p. 191.

together with ſand, and other ſubſtances that compoſe its bottom, upon land, like ſhowers of rain.

From hence, therefore, we may conceive how the violence of the ſea, and the boldneſs of the ſhore, may be ſaid to have made each other. Where the ſea meets no obſtacles, it ſpreads its waters with a gentle intumeſcence, till all its power is deſtroyed, by wanting depth to aid the motion. But when its progreſs is checked in the midſt, by the prominence of rocks, or the abrupt elevation of the land, it daſhes with all the force of its depth againſt the obſtacle, and forms, by its repeated violence, that abruptneſs of the ſhore which confines its impetuoſity. Where the ſea is extremely deep, or very much vexed by tempeſts, it is no ſmall obſtacle that can confine its rage; and for this reaſon we ſee the boldeſt ſhores projected againſt the deepeſt waters; all leſs impediments having long before been ſurmounted and waſhed away. Perhaps of all the ſhores in the world, there is not one ſo high as that on the weſt of St. Kilda, which, upon a late admeaſurement *, was found to be ſix hundred fathom perpendicular above the ſurface of the ſea. Here alſo, the ſea is deep, turbulent,

* Deſcription of St. Kilda.

and

and ſtormy; ſo that it requires great force in the ſhore to oppoſe its violence. In many parts of the world, and particularly upon the coaſts of the Eaſt Indies, the ſhores, though not high above water, are generally very deep, and conſequently the waves roll againſt the land with great weight and irregularity. This riſing of the waves againſt the ſhore, is called by mariners the ſurf of the ſea; and in ſhipwrecks is generally fatal to ſuch as attempt to ſwim on ſhore. In this caſe, no dexterity in the ſwimmer, no float he can uſe, neither ſwimming girdle nor cork jacket will ſave him; the weight of the ſuperincumbent waves break upon him at once, and cruſhes him with certain ruin. Some few of the natives, however, have the art of ſwimming and of navigating their little boats near thoſe ſhores, where an European is ſure of inſtant deſtruction.

In places where the force of the ſea is leſs violent, or its tides leſs rapid, the ſhores are generally ſeen to deſcend with a more gradual declivity. Over theſe, the waters of the tide ſteal by almoſt imperceptible degrees, covering them for a large extent, and leaving them bare on its receſs. Upon theſe ſhores, as was ſaid, the ſea ſeldom beats with any great violence, as a large wave has not depth ſufficient to float it

onwards; ſo that here only are to be ſeen gentle ſurges making calmly towards land, and leſſening as they approach. As the ſea, in the former deſcription, is generally ſeen to preſent proſpects of tumult and uproar, here it more uſually exhibits a ſcene of repoſe and tranquil beauty. Its waters, which when ſurveyed from the precipice, afforded a muddy greeniſh hue, ariſing from their depth and poſition to the eye *, when regarded from a ſhelving ſhore, wear the colour of the ſky, and ſeem riſing to meet it. The deafening noiſe of the deep ſea, is here converted into gentle murmurs; inſtead of the water's daſhing againſt the face of the rock, it advances and recedes, ſtill going forward, but with juſt force enough to puſh its weeds and ſhells, by inſenſible approaches, to the ſhore.

There are other ſhores, beſide thoſe already deſcribed, which either have been raiſed by art to oppoſe the ſea's approaches, or from the ſea's gaining ground, are threatened with imminent deſtruction. The ſea's being thus ſeen to give and take away lands at pleaſure, is, without queſtion, one of the moſt extraordinary conſiderations in all natural hiſtory. In ſome places it is ſeen to obtain the ſuperiority by ſlow and certain approaches; or to burſt in at once,

* Newton's Optics, p. 163—167.

and overwhelm all things in undiſtinguiſhed deſtruction; in other places it departs from its ſhores, and where its waters have been known to rage, it leaves fields covered with the moſt beautiful verdure.

The formation of new lands, by the ſea's continually bringing its ſediment to one place, and by the accumulation of its ſands in another, is eaſily conceived. We have had many inſtances of this in England. The iſland of Oxney, which is adjacent to Romney-marſh, was produced in this manner. This had for a long time been a low level, continually in danger of being overflown by the river Rother; but the ſea, by its depoſitions, has gradually raiſed the bottom of the river, while it has hollowed the mouth; ſo that the one is ſufficiently ſecured from inundations, and the other is deep enough to admit ſhips of conſiderable burthen. The like alſo may be ſeen at that bank called the Dogger-ſands, where two tides meet, and which thus receive new increaſe every day, ſo that in time the place ſeems to promiſe fair for being habitable earth. On many parts of the coaſts of France, England, Holland, Germany, and Pruſſia, the ſea has been ſenſibly known to retire*. Hubert Thomas aſſerts, in his Deſcription of the Country of Liege, that the

* Buffon, vol. vi. p. 424.

ſea formerly encompaſſed the city of Tongres, which, however, is at preſent thirty-five leagues diſtant from it: this aſſertion he ſupports by many ſtrong reaſons; and among others, by the iron rings fixed in the walls of the town, for faſtening the ſhips that came into the port. In Italy there is a conſiderable piece of ground gained at the mouth of the river Arno; and Ravenna, that once ſtood by the ſea-ſide, is now conſiderably removed from it. But we need ſcarce mention theſe, when we find that the whole republic of Holland ſeems to be a conqueſt upon the ſea, and in a manner reſcued from its boſom. The ſurface of the earth, in this country, is below the level of the bed of the ſea; and I remember, upon approaching the coaſt, to have looked down upon it from the ſea, as into a valley; however, it is every day riſing higher by the depoſitions made upon it by the ſea, the Rhine, and the Meuſe; and thoſe parts which formerly admitted large men of war, are now known to be too ſhallow to receive ſhips of very moderate burthen *. The province of Jucatan, a peninſula in the gulph of Mexico, was formerly a part of the ſea: this tract, which ſtretches out into the ocean an hundred leagues, and which is above thirty

* Buffon, vol. vi. p. 424.

broad, is every where, at a moderate depth below the furface, compofed of fhells, which evince that its land once formed the bed of the fea. In France, the town of Aigues Mortes was a port in the times of St. Louis, which is now removed more than four miles from the fea. Pfalmodi, in the fame kingdom, was an ifland in the year 815, but is now more than fix miles from the fhore. All along the coafts of Norfolk, I am very well affured, that in the memory of man, the fea has gained fifty yards in fome places, and has loft as much in others.

Thus numerous, therefore, are the inftances of new lands having been produced from the fea, which, as we fee, is brought about two different ways: firft, by the waters raifing banks of fand and mud where their fediment is depofited; and fecondly, by their relinquifhing the fhore entirely, and leaving it unoccupied to the induftry of man.

But as the fea has been thus known to recede from fome lands, fo has it, by fatal experience, been found to encroach upon others: and, probably, thefe depredations on one part of the fhore, may account for their dereliction from another; for the current which refted upon fome certain bank, having got an egrefs in fome other place, it no longer preffes upon its former bed,

but pours all its ſtream into the new entrance, ſo that every inundation of the ſea may be attended with ſome correſpondent dereliction of another ſhore.

However this be, we have numerous hiſtories of the ſea's inundations, and its burying whole provinces in its boſom. Many countries that have been thus deſtroyed, bear melancholy witneſs to the truth of hiſtory; and ſhew the tops of their houſes, and the ſpires of their ſteeples, ſtill ſtanding at the bottom of the water. One of the moſt conſiderable inundations we have in hiſtory, is that which happened in the reign of Henry I. which overflowed the eſtates of the Earl Godwin, and forms now that bank called the Goodwin ſands. In the year 1546, a ſimilar irruption of the ſea deſtroyed an hundred thouſand perſons in the territory of Dort; and yet a greater number round Dullart. In Friezland, and Zealand, there were more than three hundred villages overwhelmed; and their remains continue ſtill viſible at the bottom of the water in a clear day. The Baltic ſea has, by ſlow degrees, covered a large part of Pomerania; and, among others, deſtroyed and overwhelmed the famous port of Vineta. In the ſame manner, the Norwegian ſea has formed ſeveral little iſlands from the main land, and ſtill

daily advances upon the continent. The German ſea has advanced upon the ſhores of Holland, near Catt; ſo that the ruins of an ancient citadel of the Romans, which was formerly built upon this coaſt, are now actually under water. To theſe accidents ſeveral more might be added; our own hiſtorians, and thoſe of other countries, abound with them; almoſt every flat ſhore of any extent, being able to ſhew ſomething that it has loſt, or ſomething that it has gained from the ſea.

There are ſome ſhores on which the ſea has made temporary depredations; where it has overflowed, and after remaining perhaps ſome ages, it has again retired of its own accord, or been driven back by the induſtry of man*. There are many lands in Norway, Scotland, and the Maldivia iſlands, that are at one time covered with water, and at another free. The country round the Iſle of Ely, in the times of Bede, about a thouſand years ago, was one of the moſt delightful ſpots in the whole kingdom. It was not only richly cultivated, and produced all the neceſſaries of life, but grapes alſo that afforded excellent wine. The accounts of that time are copious in the deſcription of its verdure and fertility; its rich paſtures, covered

* Buffon, vol. ii. p. 425.

with flowers and herbage; its beautiful ſhades, and wholſome air. But the ſea breaking in, upon the land, overwhelmed the whole country, took poſſeſſion of the ſoil, and totally deſtroyed one of the moſt fertile vallies in the world. Its air, from being dry and healthful, from that time became moſt unwholſome, and clogged with vapours; and the ſmall part of the country that, by being higher than the reſt, eſcaped the deluge, was ſoon rendered uninhabitable, from its noxious vapours. Thus this country continued under water for ſome centuries; till, at laſt, the ſea, by the ſame caprice which had prompted its invaſions, began to abandon the earth in like manner. It has continued for ſome ages to relinquiſh its former conqueſts; and although the inhabitants can neither boaſt the longevity, nor the luxuries of their former pre-occupants, yet they find ample means of ſubſiſtence; and if they happen to ſurvive the firſt years of their reſidence there, they are often known to arrive at a good old age.

But although hiſtory be ſilent as to many other inundations of the like kind, where the ſea has overflowed the country, and afterwards retired, yet we have numberleſs teſtimonies of another nature, that prove it beyond the poſſibility of doubt: I mean thoſe numerous trees that are found buried at conſiderable depths

in places where either rivers, or the ſea, has accidentally overflown *. At the mouth of the river Neſs, near Bruges, in Flanders, at the depth of fifty feet, are found great quantities of trees lying as cloſe to each other as they do in a wood: the trunks, the branches, and the leaves, are in ſuch perfect preſervation, that the particular kind of each tree may inſtantly be known. About five hundred years ago, this very ground was known to have been covered with the ſea; nor is there any hiſtory or tradition of its having been dry ground, which we can have no doubt muſt have been the caſe. Thus we ſee a country flouriſhing in verdure, producing large foreſts, and trees of various kinds, overwhelmed by the ſea. We ſee this element depoſiting its ſediment to an height of fifty feet; and its waters muſt, therefore, have riſen much higher. We ſee the ſame, after it has thus overwhelmed, and ſunk the land ſo deep beneath its ſlime, capriciouſly retiring from the ſame coaſts, and leaving that habitable once more, which it had formerly deſtroyed. All this is wonderful; and perhaps, inſtead of attempting to enquire after the cauſe, which has hitherto been inſcrutable, it will beſt become us to reſt ſatisfied with admiration.

* Buffon, vol. ii. p. 403.

At the city of Modena in Italy, and about four miles round it, wherever it is dug, when the workmen arrive at the depth of ſixty-three feet, they come to a bed of chalk, which they bore with an augre five feet deep: they then withdraw from the pit, before the augre is removed, and upon its extraction, the water burſts up through the aperture with great violence, and quickly fills this new-made well, which continues full, and is affected neither by rains nor droughts. But that which is moſt remarkable in this operation, is the layers of earth as we deſcend. At the depth of fourteen feet, are found the ruins of an ancient city, paved ſtreets, houſes, floors, and different pieces of Moſaic. Under this is found a ſolid earth, that would induce one to think had never been removed; however, under it is found a ſoft oozy earth, made up of vegetables; and at twenty-ſix feet depth, large trees entire, ſuch as walnut-trees, with the walnuts ſtill ſticking on the ſtem, and their leaves and branches in exact preſervation. At twenty-eight feet deep, a ſoft chalk is found, mixed with a vaſt quantity of ſhells; and this bed is eleven feet thick. Under this, vegetables are found again, with leaves, and branches of trees as before; and thus alternately chalk and vegetable earth to the depth of ſixty-three

feet. These are the layers wherever the workmen attempt to bore; while in many of them, they also find pieces of charcoal, bones, and bits of iron. From this description, therefore, it appears, that this country has been alternately overflowed and deserted by the sea, one age after another: nor were these overflowings and retirings of trifling depth, or of short continuance. When the sea burst in, it must have been a long time in overwhelming the branches of the fallen forest with its sediments; and still longer in forming a regular bed of shells eleven feet over them. It must have, therefore, taken an age, at least, to make any one of these layers; and we may conclude, that it must have been many ages employed in the production of them all. The land, also, upon being deserted, must have had time to grow compact, to gather fresh fertility, and to be drained of its waters before it could be disposed to vegetation; or before its trees could have shot forth again to maturity.

We have instances nearer home of the same kind, given us in the Philosophical Transactions; one of them by Mr. Derham. An inundation of the sea, at Dagenham, in Essex, laying bare a part of the adjacent pasture, for above two hundred feet wide, and, in some places, twenty deep, it discovered a number of trees that had

lain there for many ages before; theſe trees, by lying long under ground, were become black and hard, and their fibres ſo tough, that one might as eaſily break a wire, as any of them: they lay ſo thick in the place where they were found, that in many parts he could ſtep from one to another: he conceived alſo, that not only all the adjacent marſhes, for ſeveral hundred acres, were covered underneath with ſuch timber, but alſo the marſhes along the mouth of the Thames, for ſeveral miles. The meeting with theſe trees at ſuch depths, he aſcribes to the ſediment of the river, and the tides, which conſtantly waſhing over them, have always left ſome part of their ſubſtance behind, ſo as, by repeated alluvions, to work a bed of vegetable earth over them, to the height at which he found it.

The levels of Hatfield-Chace, in Yorkſhire, a tract of above eighteen thouſand acres, which was yearly overflown, was reduced to arable and paſture-land, by one Sir Cornelius Vermuſden, a Dutchman. At the bottom of this wide extent, are found millions of the roots and bodies of trees, of ſuch as this iſland either formerly did, or does at preſent produce. The roots of all ſtand in their proper poſtures; and by them, as thick as ever they could

grow, the respective trunks of each, some above thirty yards long. The oaks, some of which have been sold for fifteen pounds a piece, are as black as ebony, very lasting, and close grained. The ash-trees are as soft as earth, and are commonly cut in pieces by the workmen's spades, and as soon as flung up into the open air, turn to dust. But all the rest, even the willows themselves, which are softer than the ash, preserve their substance and texture to this very day. Some of the firs appear to have vegetated, even after they were fallen, and to have, from their branches, struck up large trees, as great as the parent trunk. It is observable, that many of these trees have been burnt, some quite through, some on one side, some have been found chopped and squared, others riven with great wooden wedges, all sufficiently manifesting, that the country which was deluged, had formerly been inhabited. Near a great root of one tree, were found eight coins of the Roman emperors; and, in some places, the marks of the ridge and furrow were plainly perceivable, which testified that the ground had formerly been patient of cultivation.

The learned naturalist who has given this description *, has pretty plainly evinced, that

* Phil. Transf. vol. iv. part ii. p. 214.

this foreſt, in particular, muſt have been thus levelled by the Romans; and that the falling of the trees, muſt have contributed to the accumulation of the waters, "The Romans," ſays he, "when the Britons fled, always purſued them into the fortreſſes of low woods, and miry foreſts: in theſe the wild natives found ſhelter; and, when opportunity offered, iſſued out, and fell upon their invaders without mercy. In this manner, the Romans were at length ſo harraſſed, that orders were iſſued out for cutting down all the woods and foreſts in Britain. In order to effect this, and deſtroy the enemy the eaſier, they ſet fire to the woods, compoſed of pines, and other inflammable timber, which ſpreading, the conflagration deſtroyed not only the foreſt, but infinite numbers of the wretched inhabitants who had taken ſhelter therein. When the pine-trees had thus done what miſchief they could, the Romans then brought their army nearer, and, with whole legions of the captive Britons, cut down moſt of the trees that were yet left ſtanding; leaving only here and there ſome great trees untouched, as monuments of their fury. Theſe, unneedful of their labour, being deſtitute of the ſupport of the underwood, and of their neighbouring trees, were eaſily overthrown by the winds, and, without inter-

ruption, remained on the places where they happened to fall. The foreſt, thus fallen, muſt neceſſarily have ſtopped up the currents, both from land and ſea; and turned into great lakes, what were before but temporary ſtreams. The working of the waters here, the conſumption and decay of rotten boughs and branches, and the vaſt encreaſe of water-moſs which flouriſhes upon marſhy grounds, ſoon formed a covering over the trunks of the fallen trees, and raiſed the earth ſeveral feet above its former level. The earth thus every day ſwelling, by a continual encreaſe from the ſediment of the waters, and by the lightneſs of the vegetable ſubſtances of which it was compoſed, ſoon overtopt the waters by which this intumeſcence was at firſt effected; ſo that it entirely got rid of its inundations, or only demanded a ſlight aſſiſtance from man for that purpoſe." This may be the origin of all bogs, which are formed by the putrefaction of vegetable ſubſtances, mixed with the mud and ſlime depoſited by waters, and at length acquiring a ſufficient conſiſtency.

From this we ſee what powerful effects the ſea is capable of producing upon its ſhores, either by overflowing ſome, or deſerting others; by

altering the direction of theſe, and rendering thoſe craggy and precipitate, which before were ſhelving. But the influence it has upon theſe, is nothing to that which it has upon that great body of earth which forms its bottom. It is at the bottom of the ſea that the greateſt wonders are performed, and the moſt rapid changes are produced; it is there that the motion of the tides and the currents have their whole force, and agitate the ſubſtances of which their bed is compoſed. But all theſe are almoſt wholly hid from human curioſity: the miracles of the deep are performed in ſecret; and we have but little information from its abyſſes, except what we receive by inſpection at very ſhallow depths, or by the plummet, or from divers, who are known to deſcend from twenty to thirty fathom *.

The eye can reach but a very ſhort way into the depths of the ſea; and that only when its ſurface is glaſſy and ſerene. In many ſeas it perceives nothing but a bright ſandy plain at bottom, extending for ſeveral hundred miles, without an intervening object. But in others, particularly in the Red Sea, it is very different: the whole bottom of this extenſive bed of waters is, literally ſpeaking, a foreſt of ſub-

* Phil. Tranſ. vol. iv. part. ii. p. 192.

marine

marine plants, and corals formed by insects for their habitation, sometimes branching out to a great extent. Here are seen the madrepores, the sponges, mosses, sea-mushrooms, and other marine productions, covering every part of the bottom; so that some have even supposed the sea to have taken its name from the colour of its plants below. However, these plants are by no means peculiar to this sea, as they are found in great quantities in the Persian gulph, along the coasts of Africa, and those of Provence and Catalonia.

The bottom of many parts of the sea near America presents a very different, though a very beautiful appearance. This is covered with vegetables, which make it look as green as a meadow, and beneath are seen thousands of turtles, and other sea-animals, feeding thereon.

In order to extend our knowledge of the sea to greater depths, recourse has been had to the plummet; which is generally made of a lump of lead of about forty pounds weigh, fastened to a cord*. This, however, only answers in moderate depths; for when a deep sea is to be sounded, the matter of which the cord is composed, being lighter than the water, floats upon

* Buffon, vol. ii. p. 5.

it, and when let down to a confiderable depth, its length fo encreafes its furface, that it is often fufficient to prevent the lead from finking; fo that this may be the reafon that fome parts of the fea are faid to have no bottom.

In general, we learn from the plummet, that the bottom of the fea is tolerably even where it has been examined; and that the farther from the fhore, the fea is in general the deeper. Notwithftanding, in the midft of a great and unfathomable ocean, we often find an ifland raifing its head, and fingly braving its fury. Such iflands may be confidered as the mountains of the deep; and, could we for a moment imagine the waters of the ocean removed, or dried away, we fhould probably find the inequalities of its bed refembling thofe that are found at land. Here extenfive plains; there valleys; and, in many places, mountains of amazing height. M. Buache has actually given us a map of that part of its bottom, which lies between Africa and America, taken from the feveral foundings of mariners: in it we find the fame uneven furface that we do upon land, the fame eminences, and the fame depreffions. In fuch an imaginary profpect, however, there would be this difference, that, as the tops of land-mountains appear the moft barren and

rocky, the tops of ſea-mountains would be found the moſt verdant and fruitful.

The plummet, which thus gives us ſome idea of the inequalities of the bottom, leaves us totally in the dark as to every other particular; recourſe, therefore, has been had to divers: theſe, either being bred up in this dangerous way of life, and accuſtomed to remain ſome time under water without breathing, or aſſiſted by means of a diving-bell, have been able to return ſome confuſed and uncertain accounts of the places below. In the great diving-bell improved by Doctor Halley, which was large enough to contain five men, and was ſupplied with freſh air by buckets, that alternately roſe and fell, they deſcended fifty fathom. In this huge machine, which was let down from the maſt of the ſhip, the doctor himſelf went down to the bottom, where, when the ſea was clear, and eſpecially when the ſun ſhone, he could ſee perfectly well to write or read, and much more to take up any thing that was underneath: at other times, when the water was troubled and thick, it was as dark as night below, ſo that he was obliged to keep a candle lighted at the bottom. But there is one thing very remarkable: that the water which from above was uſually ſeen of a green colour, when looked at from below, ap-

peared to him of a very different one, casting a redness upon one of his hands, like that of damask roses *.—A proof of the sea's taking its colour not from any thing floating in it, but from the different reflexions of the rays of light. Upon the whole, the accounts we have received from the bottom, by this contrivance, are but few. We learn from it, and from divers in general, that while the surface of the sea may be deformed by tempests, it is usually calm and temperate below †; that some divers who have gone down when the weather was calm, and came up when it was tempestuous, were surprised at their not perceiving the change at the bottom. This, however, must not be supposed to obtain with regard to the tides, and the currents, as they are seen constantly shifting their bottom; taking their bed with great violence from one place, and depositing it upon another. We are informed, also, by divers, that the sea grows colder in proportion as they descend to the bottom; that as far as the sun's rays pierce, it is influenced by their warmth; but lower, the cold becomes almost intolerable. A person of quality, who had been himself a diver, as Mr. Boyle informs us, declared, that though he seldom descended above three or four

* Newton's Optic, p. 56. † Boyle, vol. iii. p. 242.

fathoms, yet he found it ſo much colder than near the top, that he could not well endure it; and that being let down in a great diving-bell, although the water could not immediately touch him, he found the air extremely cold upon his firſt arrival at the bottom.

From divers alſo we learn, that the ſea in many places is filled with rocks at bottom: and that among their clifts, and upon their ſides, various ſubſtances ſprout forward, which are either really vegetables, or the neſts of inſects, encreaſed to ſome magnitude. Some of theſe aſſume the ſhape of beautiful flowers; and, though ſoft, when taken up, ſoon harden, and are kept in the cabinets of the curious.

But, of all thoſe divers who have brought us information from the bottom of the deep, the famous Nicola Peſce, whoſe performances are told us by Kircher, is the moſt celebrated. I will not ſo much as pretend to vouch for the veracity of Kircher's account, which he aſſures us he had from the archives of the kings of Sicily; but it may ſerve to enliven an heavy chapter. "In the times of Frederic, king of Sicily, there lived a celebrated diver, whoſe name was Nicolas, and who, from his amazing ſkill in ſwimming, and his perſeverance under water, was ſurnamed the fiſh.

This man had, from his infancy, been used to the ſea; and earned his ſcanty ſubſiſtence by diving for corals and oyſters, which he ſold to the villagers on ſhore. His long acquaintance with the ſea, at laſt, brought it to be almoſt his natural element. He frequently was known to ſpend five days in the midſt of the waves, without any other proviſions than the fiſh which he caught there, and ate raw. He often ſwam over from Sicily to Calabria, a tempeſtuous and dangerous paſſage, carrying letters from the king. He was frequently known to ſwim among the gulphs of the Lipari iſlands, no way apprehenſive of danger.

"Some mariners out at ſea one day obſerved ſomething at ſome diſtance from them, which they regarded as a ſea-monſter; but upon its approach, it was known to be Nicolas, whom they took into their ſhip. When they aſked him whither he was going in ſo ſtormy and rough a ſea, and at ſuch a diſtance from land, he ſhewed them a packet of letters, which he was carrying to one of the towns of Italy, exactly done up in a leather bag, in ſuch a manner as that they could not be wetted by the ſea. He kept them thus company for ſome time on their voyage, converſing and aſking queſtions;

and after eating an hearty meal with them, he took his leave, and jumping into the sea, pursued his voyage alone.

"In order to aid these powers of enduring in the deep, nature seemed to have assisted him in a very extraordinary manner; for the spaces between his fingers and toes were webbed, as in a goose; and his chest became so very capacious, that he could take in at one inspiration, as much breath as would serve him for an whole day.

"The account of so extraordinary a person did not fail to reach the king himself; who, actuated by the general curiosity, ordered that Nicolas should be brought before him. It was no easy matter to find Nicolas, who generally spent his time in the solitudes of the deep; but at last, however, after much searching, he was found, and brought before his majesty. The curiosity of this monarch had been long excited by the accounts he had heard of the bottom of the gulph of Charybdis; he therefore conceived that it would be a proper opportunity to have more certain information; and commanded our poor diver to examine the bottom of this dreadful whirlpool: as an incitement to his obedience, he ordered a golden cup to be

flung into it. Nicolas was not inſenſible of the danger to which he was expoſed; dangers beſt known only to himſelf; and he therefore preſumed to remonſtrate: but the hopes of the reward, the deſire of pleaſing the king, and the pleaſure of ſhewing his ſkill, at laſt prevailed. He inſtantly jumped into the gulph, and was ſwallowed as inſtantly up in its boſom. He continued for three quarters of an hour below; during which time the king and his attendants remained upon ſhore anxious for his fate; but he at laſt appeared, buffeting upon the ſurface, holding the cup in triumph in one hand, and making his way good among the waves with the other. It may be ſuppoſed he was received with applauſe, upon his arrival on ſhore: the cup was made the reward of his adventure; the king ordered him to be taken proper care of; and, as he was ſomewhat fatigued and debilitated by his labour, after an hearty meal, he was put to bed, and permitted to refreſh himſelf by ſleeping.

"When his ſpirits were thus reſtored, he was again brought to ſatisfy the king's curioſity with a narrative of the wonders he had ſeen; and his account was to the following effect. He would never, he ſaid, have obeyed the king's commands, had he been apprized of half the

dangers that were before him. There were four things, he ſaid, that rendered the gulph dreadful, not only to men, but even to the fiſhes them ſelves: firſt, the force of the water burſting up from the bottom, which requires great ſtrength to reſiſt; ſecondly, the abruptneſs of the rocks, that on every ſide threatend deſtruction; thirdly, the force of the whirlpool, daſhing againſt thoſe rocks; and fourthly, the number and magnitude of the polypous fiſh, ſome of which appeared as large as a man, and which every where ſticking againſt the rocks, projected their fibrous arms to entangle him. Being aſked how he was able ſo readily to find the cup that had been thrown in, he replied, that it happened to be flung by the waves into the cavity of a rock, againſt which he himſelf was urged in his deſcent. This account, however, did not ſatisfy the king's curioſity: being requeſted to venture once more into the gulph for further diſcoveries, he at firſt refuſed; but the king, deſirous of having the moſt exact information poſſible of all things to be found in the gulph, repeated his ſolicitations; and, to give them ſtill greater weight, produced a larger cup than the former, and added alſo a purſe of gold. Upon theſe conſiderations, the unfortunate Peſtacola once again plunged into the whirlpool, and was never heard of more."

CHAP. XVIII.

A ſummary Account of the Mechanical Properties of Air.

HAVING deſcribed the earth and the ſea, we now aſcend into that fluid which ſurrounds them both; and which, in ſome meaſure, ſupports and ſupplies all animated nature. As upon viewing the bottom of the ocean from its ſurface, we ſee an infinity of animals moving therein, and ſeeking food; ſo were ſome ſuperior being to regard the earth at a proper diſtance, he might conſider us in the ſame light: he might, from his ſuperior ſtation, behold a number of buſy little beings, immerſed in the ærial fluid, that every where ſurrounds them, and ſedulouſly employed in procuring the means of ſubſiſtence. This fluid, though too fine for the groſs perception of its inhabitants, might, to his nicer organs of ſight, be very viſible; and, while he at once ſaw into its operations, he might ſmile at the varieties of human conjecture concerning it: he might readily diſcern, perhaps, the height above the ſurface of the earth to which this fluid atmoſphere reaches: he might exactly determine that peculiar form of its parts which gives it the ſpring or elaſticity with which it is endued: he might diſtinguiſh

which of its parts were pure incorruptible air, and which only made for a little time to assume the appearance, so as to be quickly returned back to the element from whence it came. But as for us, who are immersed at the bottom of this gulph, we must be contented with a more confined knowledge; and, wanting a proper point of prospect, remain satisfied with a combination of the effects.

One of the first things that our senses informs us of is, that although the air is too fine for our sight, it is very obvious to our touch. Although we cannot see the wind contained in a bladder, we can very readily feel its resistance; and though the hurricane may want colour, we often fatally experience that it does not want force. We have equal experience of the air's spring or elasticity; the bladder, when pressed, returns again, upon the pressure being taken away; a bottle, when filled, often bursts, from the spring of air which is included.

So far the slightest experience reaches; but, by carrying experiment a little farther, we learn, that air also is heavy: a round glass vessel being emptied of its air, and accurately weighed, has been found lighter than when it was weighed with the air in it. Upon computing the superior weight of the full vessel, a cubic foot

of air is found to weigh ſomething more than an ounce.

From this experiment, therefore, we learn, that the earth, and all things upon its ſurface, are every where covered with a ponderous fluid, which riſing very high over our heads, muſt be proportionably heavy. For inſtance, as in the ſea, a man at the depth of twenty feet, ſuſtains a greater weight of water than a man at the depth of but ten feet; ſo will a man at the bottom of a valley have a greater weight of air over him, than a man on the top of a mountain.

From hence we may conclude, that we ſuſtain a very great weight of air; and although, like men walking at the bottom of the ſea, we cannot feel the weight which preſſes equally round us, yet the preſſure is not the leſs real. As in morals, we ſeldom know the bleſſings that ſurround us till we are deprived of them, ſo here we do not perceive the weight of the ambient fluid till a part of it is taken away. If, by any means, we contrive to take away the preſſure of the air from any one part of our bodies, we are ſoon made ſenſible of the weight upon the other parts. If we clap our hand upon the mouth of a veſſel from whence the air has been taken away, there will thus be air on one ſide, and none on the other; upon which, we ſhall in-

ſtantly find the hand violently ſucked inwards, which is nothing more than the weight of the air upon the back of the hand that forces it into the ſpace which is empty below.

As by this experiment we perceive that the air preſſes with great weight upon every thing on the ſurface of the earth, ſo by other experiments we learn the exact weight with which it preſſes. First, if the air be exhauſted out of any veſſel, a drinking-veſſel for inſtance *, and this veſſel be ſet with the mouth downwards in water, the water will riſe up into the empty ſpace, and fill the inverted glaſs; for the external air will, in this caſe, preſs up the water, where there is no weight to reſiſt; as, one part of a bed being preſſed, makes the other parts, that have no weight upon them, riſe. In this caſe, as was ſaid, the water being preſſed without, will riſe in the glaſs; and would continue to riſe (if the empty glaſs were tall enough) thirty-two feet high. In fact, there have been pipes made purpoſely for this experiment of above thirty-two feet high; in which, upon being exhauſted, the water has always riſen to the height of thirty-two feet: there it has

* This may be done by burning a bit of paper in the ſame, and then quickly turning it down upon the water.

always refted, and never afcended higher. From this, therefore, we learn, that the weight of the air which preffes up the water, is equal to a pillar or column of water, which is thirty-two feet high; as it is juft able to raife fuch a column, and no more. In other words, the furface of the earth is every where covered with a weight of air, which is equivalent to a covering of thirty-two feet deep of water; or to a weight of twenty-nine inches and an half of quickfilver, which is know to be juft as heavy as the former.

Thus we fee that the air at the furface of the earth is juft as heavy as thirty-two feet of water, or twenty-nine inches and an half of quickfilver; and it is eafily found, by computation, that to raife water thirty-two feet, will require a weight of fifteen pounds upon every fquare inch. Now, if we are fond of computations, we have only to calculate how many fquare inches are in the furface of an ordinary human body, and allowing every inch to fuftain fifteen pounds, we may amaze ourfelves at the weight of air we fuftain. It has been computed, and found, that our ordinary load of air amounts to within a little of forty thoufand pounds: this is wonderful! but wondering is not the way to grow wife.

Notwithstanding this be our ordinary load, and our usual supply, there are at different times very great variations. The air is not, like water, equally heavy at all seasons; but sometimes is lighter, and sometimes more heavy. It is sometimes more comprest, and sometimes more elastic or springy, which produces the same effects as an encrease of its weight. The air which at one time raises water thirty-two feet in the tube, and quicksilver twenty-nine inches, will not at another raise the one to thirty feet, or the other to twenty-six inches. This makes, therefore, a very great difference in the weight we sustain; and we are actually known, by computation, to carry at one time four thousand pounds of air more than at another.

The reason of this surprising difference in the weight of air, is either owing to its pressure from above, or to an encrease of vapour floating in it. It encreased pressure is the consequence of its spring or elasticity, which cold and heat sensibly affect, and are continually changing.

This elasticity of the air is one of its most amazing properties; and to which it should seem nothing can set bounds. A body of air that may be contained in a nut-shell, may easily, with heat, be dilated into a sphere of unknown dimensions. On the contrary, the air contained

in an houſe, may be compreſſed into a cavity not larger than the eye of a needle. In ſhort, no bounds can be ſet to its confinement or expanſion; at leaſt, experiment has hitherto found its attempts indefinite. In every ſituation, it retains its elaſticity; and the more cloſely we compreſs it, the more ſtrongly does it reſiſt the preſſure. If to the encreaſing the elaſticity on one ſide by compreſſion, we encreaſe in on the other ſide by heat, the force of both ſoon becomes irreſiſtible; and a certain French philoſopher ſuppoſed *, that air thus confined, and expanding, was ſufficient for the exploſion of a world.

Many inſtruments have been formed to meaſure and determine theſe different properties of the air; and which ſerve ſeveral uſeful purpoſes. The barometer ſerves to meaſure its weight; to tell us when it is heavier, and when lighter. It is compoſed of a glaſs tube or pipe, of about thirty inches in length, cloſed up at one end; this tube is then filled with quickſilver; this done, the maker clapping his finger upon the open end, inverts the tube, and plunges the open end, finger and all, into a baſon of quickſilver, and then takes his finger away: now the quickſilver in the tube will, by its own weight,

* Monſieur Amontons.

endeavour to deſcend into that in the baſon; but the external air, preſſing on the ſurface of the quickſilver in the baſon without, and no air being in the tube at top, the quickſilver will continue in the tube, being preſſed up, as was ſaid, by the air, on the ſurface of the baſon below. The height at which it is known to ſtand in the tube, is uſually about twenty-nine inches, when the air is heavy; but not above twenty-ſix, when the air is very light. Thus, by this inſtrument we can, with ſome exactneſs, determine the weight of the air; and, of conſequence, tell before-hand the changes of the weather. Before fine dry weather, the air is charged with a variety of vapours, which float in it unſeen, and render it extremely heavy, ſo that it preſſes up the quickſilver; or, in other words, the barometer riſes. In moiſt, rainy weather, the vapours are waſhed down, or there is not heat ſufficient for them to riſe, ſo that the air is then ſenſibly lighter, and preſſes up the quickſilver with leſs force; or, in other words, the barometer is ſeen to fall. Our conſtitutions ſeem alſo to correſpond with the changes of the weather-glaſs; they are braced, ſtrong, and vigorous, with a large body of air upon them; they are languid, relaxed, and feeble, when the

air is light, and refuſes to give our fibres their proper tone.

But although the barometer thus meaſures the weight of the air with exactneſs enough for the general purpoſes of life, yet it is often affected with a thouſand irregularities, that no exactneſs in the inſtrument can remedy, nor no theory account for. When high winds blow, the quickſilver generally is low: it riſes higher in cold weather than in warm; and is uſually higher at morning and evening than at mid-day: it generally deſcends lower after rain than it was before it. There are alſo frequent changes in the air, without any ſenſible alteration in the barometer.

As the barometer is thus uſed in predicting the changes of the weather, ſo it is alſo ſerviceable in meaſuring the heights of mountains, which mathematicians cannot ſo readily do: for, as the higher we aſcend from the ſurface of the earth, the air becomes lighter, ſo the quickſilver in the barometer will deſcend in proportion. It is found to ſink at the rate of the tenth part of an inch for every ninety feet we aſcend; ſo that in going up a mountain, if I find the quickſilver fallen an inch, I conclude, that I am got upon an aſcent of near nine hundred feet high. In this there has been found ſome variation; into a de-

tail of which, it is not the buſineſs of a natural hiſtorian to enter.

In order to determine the elaſticity of air, the wind-gun has been invented, which is an inſtrument variouſly made; but in all upon the principle of compreſſing a large quantity of air into a tube, in which there is an ivory ball, and then giving the compreſſed elaſtic air free power to act, and drive the ball as directed. The ball thus driven, will pierce a thick board: and will be as fatal, at ſmall diſtances, as if driven with gunpowder. I do not know whether ever the force of this inſtrument has been aſſiſted by means of heat; certain I am, that this, which could be very eaſily contrived by means of phoſphorus, or any other hot ſubſtance applied to the barrel, would give ſuch a force as I doubt whether gunpowder itſelf could produce.

The air pump is an inſtrument contrived to exhauſt the air from round a veſſel adapted to that purpoſe, called a receiver. This method of exhauſting, is contrived in the ſimple inſtrument, by a piſton, like that of a ſyringe, going down into the veſſel, and thus puſhing out its air; which, by means of a valve, is prevented from returning into the veſſel again. But this, like all other complicated inſtruments, will be better underſtood by a minute inſpection, than

an hour's defcription: it may fuffice here to obferve, that by depriving animals, and other fubftances, of all air, it fhews us what the benefits and effects of air are in fuftaining life, or promoting vegetation.

The digefter is an inftrument of ftill more extraordinary effects than any of the former; and fufficiently difcovers the amazing force of air, when its elafticity is augmented by fire. A common tea-kettle, if the fpout were clofed up, and the lid put firmly down, would ferve to become a digefter, if ftrong enough. But the inftrument ufed for this purpofe, is a ftrong metal pot, with a lid to fcrew clofe on, fo that, when down, no air can get in or return: into this pot meat and bones are put, with a fmall quantity of water, and then the lid fcrewed clofe: a lighted lamp is put underneath, and, what is very extraordinary, (yet equally true), in fix or eight minutes the whole mafs, bones and all, are diffolved into a jelly; fo great is the force and elafticity of the air contained within, ftruggling to efcape, and breaking in pieces all the fubftances with which it is mixed. Care, however, muft be taken not to heat this inftrument too violently; for then, the inclofed air would become irrefiftible, and burft the whole, with perhaps a fatal explofion.

4

There are numberleſs other uſeful inſtruments made to depend on the weight, the elaſticity, or the fluidity of the air, which do not come within the plan of the preſent work; the deſign of which is not to give an account of the inventions that have been made for determining the nature and properties of air, but a mere narration of its effects. The deſcription of the pump, the forcing-pump, the fire-engine, the ſteam-engine, the ſyphon, and many others, belong not to the naturaliſt, but the experimental philoſopher: the one gives an hiſtory of Nature, as he finds ſhe preſents herſelf to him; and he draws the obvious picture: the other purſues her with cloſe inveſtigation, tortures her by experiment to give up her ſecrets, and meaſures her latent qualities with laborious preciſion. Much more, therefore, might be ſaid of the mechanical effects of air, and of the conjectures that have been made reſpecting the form of its parts; how ſome have ſuppoſed them to reſemble little hoops, coiled up in a ſpring; others, like fleeces of wool; others, that the parts are endued with a repulſive quality, by which, when ſqueezed together, they endeavour to fly off, and recede from each other. We might have given the diſputes relative to the

height to which this body of air extends above us, and concerning which there is no agreement. We might have enquired how much of the air we breathe is elementary, and not reducible to any other ſubſtance; and of what denſity it would become, if it were ſuppoſed to be continued down to the center of the earth. At that place we might, with the help of figures, and a bold imagination, have ſhewn it twenty thouſand times heavier than its bulk of gold. We might alſo prove it millions of times purer than upon earth, when raiſed to the ſurface of the atmoſphere. But theſe ſpeculations do not belong to natural hiſtory; and they have hitherto produced no great advantages in that branch of ſcience to which they more properly appertain.

CHAP.

CHAP. XIX.

An Eſſay towards a Natural Hiſtory of the Air.

A Late eminent philoſopher has conſidered our atmoſphere as one large chemical veſſel, in which an infinite number of various operations are conſtantly performing. In it all the bodies of the earth are continually ſending up a part of their ſubſtance by evaporation, to mix in this great alembic, and to float a-while in common. Here minerals, from their loweſt depths, aſcend in noxious, or in warm vapours, to make a part of the general maſs; ſeas, rivers, and ſubterraneous ſprings, furniſh their copious ſupplies; plants receive and return their ſhare; and animals, that by living upon, conſume this general ſtore, are found to give it back in greater quantities, when they die *. The air, therefore, that we breathe, and upon which we ſubſiſt, bears very little reſemblance to that pure elementary body which was deſcribed in the laſt chapter; and which is rather a ſubſtance that may be conceived, than experienced to exiſt. Air, ſuch as we find it, is one of the moſt compounded bodies in all nature. Water may be reduced to

* Boyle, vol. ii. p. 593.

a fluid every way reſembling air, by heat; which, by cold, becomes water again. Every thing we ſee gives off its parts to the air, and has a little floating atmoſphere of its own round it. The roſe is encompaſſed with a ſphere of its own odorous particles; while the night-ſhade infects the air with ſcents of a more ungrateful nature. The perfume of muſk goes off in ſuch abundance, that the quantity remaining becomes ſenſibly lighter by the loſs. A thouſand ſubſtances that eſcape all our ſenſes, we know to be there; the powerful emanations of the load-ſtone, the effluvia of electricity, the rays of light, and the inſinuations of fire. Such are the various ſubſtances through which we move, and which we are conſtantly taking in at every pore, and returning again with imperceptible diſcharge!

This great ſolution, or mixture of all earthly bodies, is continually operating upon itſelf; which, perhaps, may be the cauſe of its unceaſing motion: but it operates ſtill more viſibly upon ſuch groſſer ſubſtances as are expoſed to its influence; for ſcarce any ſubſtance is found capable of reſiſting the corroding qualities of the air. The air, ſay the chemiſts, is a chaos, furniſhed with all kinds of ſalts and menſtruums; and, therefore, it is capable of diſſolving all

kinds of bodies. It is well known, that copper and iron are quickly covered, and eaten with ruft; and that in the climates near the equator, no art can keep them clean. In thofe dreary countries, the inftruments, knives and keys, that are kept in the pocket, are neverthelefs quickly encrufted; and the great guns, with every pre-caution, after fome years, become ufelefs. Stones, as being lefs hard, may be readily fup-pofed to be more eafily foluble. The marble of which the noble monuments of Italian an-tiquity are compofed, although in one of the fineft climates in the world, fhew the impref-fions which have been made upon them by the air. In many places they feem worm-eaten by time; and, in others, they appear crumbling into duft. Gold alone feems to be exempted from this general ftate of diffolution; it is never found to contract ruft, though expofed never fo long: the reafon of this feems to be, that fea-falt, which is the only menftruum capable of act-ing upon, and diffolving gold, is but very little mixed with the air; for falt being a very fixed body, and not apt to volatilize, and rife with heat, there is but a fmall proportion of it in the atmofphere. In the elaboratories, and fhops, however, where falt is much ufed, and the air

is impregnated with it, gold is found to ruſt as well as other metals.

Bodies of a ſofter nature are obviouſly deſtroyed by the air *. Mr. Boyle ſays, that ſilks brought to Jamaica, will, if there expoſed to the air, rot even while they preſerve their colour; but if kept therefrom, they both retain their ſtrength and gloſs. The ſame happens in Braſil, where their cloaths, which are black, ſoon turn of an iron colour; though, in the ſhops, they preſerve their proper hue †. In theſe tropical climates alſo, ſuch are the putreſcent qualities of the air, that white ſugar will ſometimes be full of maggots. Drugs and plaſters loſe their virtue, and become verminous. In ſome places they are obliged to expoſe their ſweetmeats by day in the ſun, otherwiſe the night air would quickly cauſe them to putrefy. On the contrary, in the cold arctic regions, animal ſubſtances, during their winter, are never known to putrefy; and meat may be kept for months, without any ſalt whatſoever. This experiment happily ſucceeded with the eight Engliſhmen that were accidentally left upon the inhoſpitable coaſts of Greenland, at a place where ſeven Dutchmen had periſhed but a few years before; for killing ſome rein-deer for their ſubſiſtence,

* Buffon, vol. iii. p. 62. † Ibid. vol. iii. p. 68.

and having no ſalt to preſerve the fleſh, to their great ſurprize, they ſoon found it did not want any, as it remained ſweet during their eight months continuance upon that ſhore.

Theſe powers with which air is endued over unorganized ſubſtances, are exerted in a ſtill ſtronger manner over plants, animals of an inferior nature, and, laſtly, over man himſelf. Moſt of the beauty, and the luxuriance of vegetation, is well known to be derived from the benign influence of the air: and every plant ſeems to have its favourite climate, not leſs than its proper ſoil. The lower ranks of animals alſo, ſeem formed for their reſpective climates, in which only they can live. Man alone ſeems the child of every climate, and capable of exiſting in all. However, this peculiar privilege does not exempt him from the influences of the air; he is as much ſubject to its malignity, as the meaneſt inſect or vegetable.

With regard to plants, air is ſo abſolutely neceſſary for their life and preſervation, that they will not vegetate in an exhauſted receiver. All plants have within them a quantity of air, which ſupports and agitates their juices. They are continually imbibing freſh nutriment from the air, to encreaſe this ſtore, and to ſupply the wants which they ſuſtain from evaporation. When,

therefore, the external air is drawn from them, they are no longer able to ſubſiſt. Even that quantity of air which they before were poſſeſſed of, eſcapes through their pores, into the exhauſted receiver; and as this continues to be pumped away, they become languid, grow flaccid, and die. However, the plant or flower thus ceaſing to vegetate, is kept, by being ſecured from the external air, a much longer time ſweet than it would have continued, had it been openly expoſed.

That air which is ſo neceſſary to the life of vegetables, is ſtill more ſo to that of animals; there are none found, how ſeemingly torpid ſoever, that do not require their needful ſupply. Fiſhes themſelves will not live in water from whence the air is exhauſted; and it is generally ſuppoſed that they die in frozen ponds, from the want of this neceſſary to animal exiſtence. Many have been the animals that idle curioſity has tortured in the priſon of a receiver, merely to obſerve the manner of their dying. We ſhall, from a thouſand inſtances, produce that of the viper, as it is known to be one of the moſt vivacious reptiles in the world; and as we ſhall feel but little compaſſion for its tortures. Mr. Boyle took a new-caught viper, and ſhutting it up into a ſmall receiver, began to pump away

the air *. "At firſt, upon the air's being drawn away, it began to ſwell; ſome time after he had done pumping, it began to gape, and open its jaws; being thus compelled to open its jaws, it once more reſumed its former lankneſs; it then began to move up and down within, as if to ſeek for air, and after a while foamed a little; leaving the foam ſticking to the inſide of the glaſs; ſoon after the body and neck grew prodigiouſly tumid, and a bliſter appeared upon its back; an hour and an half after the receiver was exhauſted, the diſtended viper moved, and gave manifeſt ſigns of life; the jaws remained quite diſtended; as it were from beneath the epiglottis, came the black tongue, and reached beyond it; but the animal ſeemed, by its poſture, not to have any life: the mouth alſo was grown blackiſh within; and in this ſituation it continued for twenty-three hours. But upon the air's being re-admitted, the viper's mouth was preſently cloſed, and ſoon after opened again; and for ſome time thoſe motions continued, which argued the remains of life." Such is the fate of the moſt inſignificant or minute reptile that can be thus included. Mites, fleas, and even the little eels that are found ſwimming in vinegar, die for want of air. Not only theſe, but the eggs

* Boyle's Phyſico-Mechan. Exper. paſſim.

of theſe animals, will not produce in vacuo, but require air to bring them to perfection.

As in this manner air is neceſſary to their ſubſiſtence, ſo alſo it muſt be of a proper kind, and not impregnated with foreign mixtures. That factitious air which is pumped from plants or fluids, is generally, in a ſhort time, fatal to them. Mr. Boyle has given us many experiments to this purpoſe. After having ſhewn that all vegetable, and moſt mineral ſubſtances, properly prepared, may afford air, by being placed in an exhauſted receiver, and this in ſuch quantities, that ſome have thought it a new ſubſtance, made by the alteration which the mineral or plant has undergone by the texture of its parts being looſened in the operation—having ſhewn, I ſay, that this air may be drawn in great quantities from vegetable, animal, or mineral ſubſtances, ſuch as apples, cherries, amber burnt, or hartſhorn *—he included a frog in artificial air, produced from paſte; in ſeven minutes ſpace it ſuffered convulſions, and at laſt lay ſtill, and being taken out, recovered no motion at all, but was dead. A bird encloſed in artificial air, from raiſins, died in a quarter of a minute, and never ſtirred more. A ſnail was put into the receiver, with air of paſte; in four

* Boyle's Phyſico-Mechan. vol. ii. p. 598.

minutes it ceafed to move, and was dead, although it had furvived in vacuo for feveral hours: fo that factitious air proved a greater enemy to animals than even a vacuum itfelf.

Air alfo may be impregnated with fumes that are inftantly fatal to animals. The fumes of hot iron, copper, or any other heated metal, blown into the place where an animal is confined, inftantly deftroy it. We have already mentioned the vapours in the grotto Del Cane fuffocating a dog. The ancients even fuppofed, that thefe animals, as they always ran with their nofes to the ground, were the firft that felt any infection. In fhort, it fhould feem that the predominance of any one vapour, from any body, how wholfome foever in itfelf, becomes infectious; and that we owe the falubrity of the air to the variety of its mixture.

But there is no animal whofe frame is more fenfibly affected by the changes of the air than man. It is true, he can endure a greater variety of climates than the lower orders generally are able to do; but it is rather by the means which he has difcovered of obviating their effects, than by the apparent ftrength of his conftitution. Moft other animals can bear cold or hunger better, endure greater fatigues in proportion, and are fatisfied with fhorter repofe.

The variations of the climate, therefore, would probably effect them lefs, if they had the fame means or fkill in providing againft the feverities of the change. However this be, the body of man is an inftrument much more nicely fenfible of the variations of the air, than any of thofe which his own art has produced; for his frame alone feems to unite all their properties, being invigorated by the weight of the air, relaxed by its moifture, enfeebled by its heat, and ftiffened by its frigidity.

But it is chiefly by the predominance of fome peculiar vapour, that the air becomes unfit for human fupport. It is often found, by dreadful experience, to enter into the conftitution, to mix with its juices, and to putrefy the whole mafs of blood. The nervous fyftem is not lefs affected by its operations; palfies and vertigoes are caufed by its damps; and a ftill more fatal train of diftempers by its exhalations. In order that the air fhould be wholefome, it is neceffary as we have feen, that it fhould not be of one kind, but the compound of feveral fubftances; and the more various the compofition, to all appearance the more falubrious. A man, therefore, who continues in one place, is not fo likely to enjoy this wholefome variety, as he who changes his fituation; and, if I may fo exprefs it, inftead of

of waiting for a renovation of air, walks forward to meet his arrival. This mere motion, independent even of the benefits of exercife, becomes wholfome, by thus fupplying a great variety of that healthful fluid by which we are fuftained.

A thoufand accidents are found to encreafe thefe bodies of vapour, that make one place more or lefs wholefome than another. Heat may raife them in too great quantities; and cold may ftagnate them. Minerals may give off their effluvia in fuch proportion as to keep away all other kind of air; vegetables may render the air unwholefome by their fupply; and animal putrefaction feems to furnifh a quantity of vapour, at leaft as noxious as any of the former. All thefe united, generally make up the mafs of refpiration, and are, when mixed together, harmlefs; but any one of them, for a long time fingly predominant, becomes at length fatal.

The effects of heat in producing a noxious quality in the air, are well known. Thofe torrid regions under the Line are always unwholefome. At Senegal, I am told, the natives confider forty as a very advanced time of life, and generally die of old age at fifty. At Carthagena *, in America, where the heat of the hotteft day ever

* Ulloa, vol. i. p. 42.

known in Europe is continual, where, during their winter ſeaſon, theſe dreadful heats are united with a continual ſucceſſion of thunder, rain, and tempeſts, ariſing from their intenſeneſs, the wan and livid complexions of the inhabitants might make ſtrangers ſuſpect that they were juſt recovered from ſome dreadful diſtemper; the actions of the natives are conformable to their colour; in all their motions there is ſomewhat relaxed and languid; the heat of the climate even affects their ſpeech, which is ſoft and ſlow, and their words generally broken. Travellers from Europe retain their ſtrength and ruddy colour in that climate, poſſibly for three or four months; but afterwards ſuffer ſuch decays in both, that they are no longer to be diſtinguiſhed from the inhabitants by their complexion. However, this languid and ſpiritleſs exiſtence is frequently drawled on ſometimes even to eighty. Young perſons are generally moſt affected by the heat of climate, which ſpares the more aged; but all, upon their arrival on the coaſts, are ſubject to the ſame train of fatal diſorders. Few nations have experienced the mortality of theſe coaſts, ſo much as our own: in our unſucceſsful attack upon Carthagena, more than three parts of our army were deſtroyed by the climate alone; and thoſe that returned from

that fatal expedition, found their former vigour irretrivably gone. In our more fortunate expedition, which gave us the Havannah, we had little reaſon to boaſt of our ſucceſs; inſtead of a third, not a fifth part of the army were left ſurvivors of their victory, the climate being an enemy that even heroes cannot conquer.

The diſtempers that thus proceed from the cruel malignity of thoſe climates are many; that, for inſtance, called the Chapotonadas, carries off a multitude of people; and extremely thins the crews of European ſhips, whom gain tempts into thoſe inhoſpitable regions. The nature of this diſtemper is but little known, being cauſed in ſome perſons by cold, in others by indigeſtion. But its effects are far from being obſcure; it is generally fatal in three or four days: upon its ſeizing the patient, it brings on what is there called the black vomit, which is the ſad ſymptom after which none are ever found to recover. Some, when the vomit attacks them, are ſeized with a delirium, that, were they not tied down, they would tear themſelves to pieces, and thus expire in the midſt of this furious paroxyſm. This diſorder, in milder climates, takes the name of the bilious fever, and is intended with milder ſymptoms, but very dangerous in all.

There are many other diſorders incident to the human body, that ſeem the offspring of heat; but to mention no other, that very laſſitude which prevails in all the tropical climates, may be conſidered as a diſeaſe. The inhabitants of India*, ſays a modern philoſopher, ſuſtain an unceaſing languor, from the heats of their climate; and are torpid in the midſt of profuſion. For this reaſon, the great Diſpoſer of Nature has cloathed their country with trees of an amazing height, whoſe ſhade might defend them from the beams of the ſun; and whoſe continual freſhneſs might, in ſome meaſure, temperate their fierceneſs. From theſe ſhades, therefore, the air receives refreſhing moiſture, and animals a cooling protection. The whole race of ſavage animals retire, in the midſt of the day, to the very center of the foreſts, not ſo much to avoid their enemy man, as to find a defence againſt the raging heats of the ſeaſon. This advantage which ariſes from ſhade in torrid climates, may probably afford a ſolution for that extraordinary circumſtance related by Boyle, which he imputes to a different cauſe. In the iſland of Ternate, belonging to the Dutch, a place that had been long celebrated for its beauty and healthfulneſs, the clove-trees grew in ſuch plenty, that they in

* Linnæi Amaenitates, vol. v. p. 4.4.

ſome meaſure leſſened their own value: for this reaſon, the Dutch reſolved to cut down the foreſts, and thus to raiſe the price of the commodity: but they had ſoon reaſon to repent of their avarice; for ſuch a change enſued, by cutting down the trees, that the whole iſland, from being healthy and delightful, having loſt its charming ſhades, became extremely ſickly, and has actually continued ſo to this day. Boerhaave conſidered heat ſo prejudical to health, that he was never ſeen to go near a fire.

An oppoſite ſet of calamities are the conſequence, in climates where the air is condenſed by cold. In ſuch places, all that train of diſtempers which are known to ariſe from obſtructed perſpiration, are very common*; eruptions, boils, ſcurvy, and a loathſome leproſy, that covers the whole body with a ſcurf, and white putried ulcers. Theſe diſorders alſo are infectious; and, while they thus baniſh the patient from ſociety, they generally accompany him to the grave. The men of thoſe climates ſeldom attain to the age of fifty; but the women, who do not lead ſuch laborious lives, are found to live longer.

The autumnal complaints which attend a wet

* Krantz's Hiſtory of Greenland, vol. i. p. 235.

ſummer, indicate the dangers of a moiſt air. The long continuance of an eaſt wind alſo, ſhews the prejudice of a dry one. Mineral exhalations, when copious, are every where known to be fatal; and although we probably owe the increaſe and luxuriance of vegetation to a moderate degree of their warmth, yet the natives of thoſe countries where there are mines in plenty, but too often experience the noxious effects of their vicinity. Thoſe trades alſo that deal in the preparations of metals of all kinds, are always unwholſome; and the workmen, after ſome time, are generally ſeen to labour under palſies, and other nervous complaints. The vapours from ſome vegetable ſubſtances, are well known to be attended with dangerous effects. The ſhade of the machinel-tree, in America, is ſaid to be fatal; as was that of the juniper, if we may credit the ancients. Thoſe who walk through fields of poppies, or in any manner prepare thoſe flowers for making opium, are very ſenſibly affected with the drowſineſs they occaſion. A phyſician of Mr. Boyle's acquaintance, cauſing a large quantity of black hellebore to be pounded in a mortar, moſt of the perſons who were in the room, and eſpecially the perſon who pounded it, were purged by it, and ſome of them ſtrongly. He alſo gathered a certain plant in Ireland, which the perſon who beat in a mortar, and the

physician who was standing near, were so strongly affected by, that their hands and faces swelled to an enormous size, and continued tumid for a long time after.

But neither mineral nor vegetable steams are so dangerous to the constitution, as those proceeding from animal substances, putrefying either by disease or death. The effluvia that comes from diseased bodies, propagate that frightful catalogue of disorders which are called infectious. The parts which compose vegetable vapours, and mineral exhalations, seem gross and heavy, in comparison of these volatile vapours, that go to great distances, and have been described as spreading desolation over the whole earth. They fly every where; penetrate every where; and the vapours that fly from a single disease, soon render it epidemic.

The plague is the first upon the list in this class of human calamities. From whence this scourge of man's presumption may have its beginning, is not well known; but we well know that it is propagated by infection. Whatever be the general state of the atmosphere, we learn, from experience, that the noxious vapours, though but singly introduced at first, taints the air by degrees: every person infected, tends to add to the growing malignity;

and, as the diſorder becomes more general, the putreſcence of the air becomes more noxious, ſo that the ſymptoms are aggravated by continuance. When it is ſaid that the origin of this diſorder is unknown, it implies, that the air ſeems to be but little employed in firſt producing it. There are ſome countries, even in the midſt of Africa, that we learn have never been infected with it; but continue, for centuries, unmoleſted. On the contrary, there are others, that are generally viſited once a year, as in Egypt, which, nevertheleſs, ſeems peculiarly bleſſed with the ſerenity and temperature of its climate. In the former countries, which are of vaſt extent, and many of them very populous, every thing ſhould ſeem to diſpoſe the air to make the plague continual among them. The great heats of the climate, the unwholeſomeneſs of the food, the ſloth and dirt of the inhabitants, but, above all, the bloody battles which are continually fought among them, after which heaps of dead bodies are left unburied, and expoſed to putrefaction. All theſe one might think would be apt to bring the plague among them; and yet, nevertheleſs, we are aſſured by Leo Africanus, that in Numidia the plague is not known once in an hundred years; and that in Negroland, it is not known at all. This dreadful diſorder, therefore, muſt have its riſe, not

from any previous diſpoſition of the air, but from ſome particular cauſe, beginning with one individual, and extending the malignity, by communication, till at laſt the air becomes actually tainted by the generality of the infection.

The plague which ſpread itſelf over the whole world, in the year 1346, as we are told by Mezeray, was ſo contagious, that ſcarce a village, or even an houſe, eſcaped being infected by it. Before it had reached Europe, it had been for two years travelling from the great kingdom of Cathay, where it began by a vapour moſt horridly fetid; this broke out of the earth like a ſubterranean fire, and upon the firſt inſtant of its eruption, conſumed and deſolated above two hundred leagues of that country, even to the trees and ſtones.

In that great plague which deſolated the city of London, in the year 1665, a pious and learned ſchoolmaſter of Mr. Boyle's acquaintance, who ventured to ſtay in the city, and took upon him the humane office of viſiting the ſick and the dying, who had been deſerted by better phyſicians, averred, that being once called to a poor woman who had buried her children of the plague, he found the room where ſhe lay ſo little that it ſcarce could hold any more than the bed whereon ſhe was ſtretched. However, in this

wretched abode, beſide her, in an open coffin, her huſband lay, who had ſome time before died of the ſame diſeaſe; and whom ſhe, poor creature, ſoon followed. But what ſhewed the peculiar malignity of the air, thus ſuffering from animal putrefaction, was, that the contagious ſteams had produced ſpots on the very wall of their wretched apartment: and Mr. Boyle's own ſtudy, which was contiguous to a peſt-houſe, was alſo ſpotted in the ſame frightful manner. Happily for mankind, this diſorder, for more than a century, has not been known in our iſland; and, for this laſt age, has abated much of its violence, even in thoſe countries where it is moſt common. Diſeaſes, like empires, have their revolutions; and thoſe which for a while were the ſcourge of mankind, ſink unheard of, to give place to new ones, more dreadful, as being leſs underſtood.

For this revolution in diſorders, which has employed the ſpeculation of many, Mr. Boyle accounts in the following manner: "Since," ſays he, "there want not cauſes in the bowels of the earth, to make conſiderable changes amongſt the materials that nature has plentifully treaſured up in thoſe magazines, and as thoſe noxious ſteams are abundantly ſupplied to the ſurface, it may not ſeem improbable, that in this

great variety, ſome may be found capable of particularly affecting the human frame in a particular manner, and thus of producing new diſeaſes. The duration of theſe may be greater or leſs, according to the laſtingneſs of thoſe ſubterraneous cauſes that produced them. On which account, it need be no wonder that ſome diſeaſes have but a ſhort duration, and vaniſh not long after they appear; whilſt others may continue longer, as having under ground more ſettled and durable cauſes to maintain them."

From the recital of this train of miſchiefs produced by the air, upon minerals, plants, animals, and man himſelf, a gloomy mind may be apt to dread this indulgent nurſe of nature as a cruel and an inexorable ſtep-mother: but it is far otherwiſe; and, although we are ſometimes injured, yet almoſt all the comforts and bleſſings of life ſpring from its propitious influence. It would be needneſs to obſerve, that it is abſolutely neceſſary for the ſupport of our lives; for of this, every moment's experience aſſures us. But how it contributes to this ſupport, is not ſo readily comprehended. All allow it to be a friend, to whoſe benefits we are conſtantly obliged: and yet, to this hour, philoſophers are divided as to the nature of the obligation. The diſpute is, whether the air is only uſeful by its weight to

force our juices into circulation*; or, whether, by containing a peculiar ſpirit, it mixes with the blood in our veſſels, and acts like a ſpur to their induſtry †. Perhaps it may exert both theſe uſeful offices at the ſame time. Its weight may give the blood its progreſſive motion, through the larger veſſels of the body; and its admixture with it, cauſe thoſe contractions of all the veſſels, which ſerve to force it ſtill more ſtrongly forward, through the minuteſt channels of the circulation. Be this as it may, it is well known, that that part of our blood which has juſt received the influx of the air in our bodies, is of a very different colour from that which has almoſt performed its circuit. It has been found, that the arterial blood which has been immediately mixed with the air in the lungs, and, if I may ſo expreſs it, is juſt beginning it journey through the body, is of a fine florid ſcarlet colour; while, on the contrary, the blood of the veins that is returning from having performed its duty, is of a blackiſh crimſon hue. Whence this difference of colour ſhould proceed, is not well underſtood; we only know the fact, that this florid colour is communicated by the air; and we are well con-

* Keil. Robinſon.

† Whytt upon vital and involuntary Motions.

vinced, that this air has been admitted into the blood for very useful purposes.

Besides this vital principle in animals, the air also gives life and body to flame. A candle quickly goes out in an exhausted receiver; for having soon consumed the quantity of air, it then expires, for want of a fresh supply. There has been a flame contrived that will burn under water; but none yet has been found, that will continue to burn without air. Gunpowder, which is the most catching and powerful fire we know, will not go off in an exhausted receiver; nay, if a train of gunpowder be laid, so as that one part may be fired in the open air, yet the other part in vacuo will remain untouched, and unconsumed. Wood also set on fire, immediately goes out; and its flame ceases upon removing the air; for something is then wanting to press the body of the fire against that of the fuel, and to prevent the too speedy diffusion of the flame. We frequently see cooks, and others, whose business it is to keep up strong fires, take proper precautions to exclude the beams of the sun from shining upon them, which effectually puts them out. This they are apt to ascribe to a wrong cause; namely, the operation of the light: but the real fact is, that

the warmth of the ſun-beams leſſen and diſſipate the body of the air that goes to feed the flame; and the fire, of conſequence, languiſhes for want of a neceſſary ſupply.

The air, while it thus kindles fire into flame, is notwithſtanding found to moderate the rays of light, to diſſipate their violence, and to ſpread an uniform luſtre over every object. Were the beams of the ſun to dart directly upon us, without paſſing through this protecting medium, they would either burn us up at once, or blind us with their effulgence. But by going through the air, they are reflected, refracted, and turned from their direct courſe, a thouſand different ways; and thus are more evenly diffuſed over the face of nature.

Among the other neceſſary benefits the air is of to us, one of the principal is its conveyance of ſound. Even the vibrations of a bell, which have the loudeſt effect that we know of, ceaſes to be heard, when under the receiver of an air-pump. Thus all the pleaſures we receive from converſation with each other, or from muſic, depend entirely upon the air.

Odours likewiſe are diffuſed only by the means of air; without this fluid to ſwim in, they would for ever remain torpid in their reſpective

ſubſtances; and the roſe would affect us with as little ſenſations of pleaſure, as the thorn on which it grew.

Thoſe who are willing to augment the catalogue of the benefits we receive from this element, aſſert alſo, that taſtes themſelves would be inſipid, were it not that the air preſſes their parts upon the nerves of the tongue and palate, ſo as to produce their grateful effects. Thus, continue they, upon the tops of high mountains, as on the Pike of Teneriff, the moſt poignant bodies, as pepper, ginger, ſalt, and ſpice, have no ſenſible taſte, for want of their particles being thus ſent home to the ſenſory. But we owe the air ſufficient obligations, not to be ſtudious of admitting this among the number: in fact, all ſubſtances have their taſte, as well on the tops of mountains, as in the bottom of the valley; and I have been one of many, who have ate a very ſavoury dinner on the Alps.

It is ſufficient, therefore, that we regard the air as the parent of health and vegetation; as a kind diſpenſer of light and warmth; and as the conveyer of ſounds and odours. This is an element of which avarice will not deprive us; and which power cannot monopolize. The treaſures of the earth, the verdure of the fields,

and even the refreſhments of the ſtream, are too often ſeen going only to aſſiſt the luxuries of the great; while the leſs fortunate part of mankind ſtand humble ſpectators of their encroachments. But the air no limitations can bound, nor any land-marks reſtrain. In this benign element, all mankind can boaſt an equal poſſeſſion; and for this we all have equal obligations to Heaven. We conſume a part of it, for our own ſuſtenance, while we live; and, when we die, our putrefying bodies give back the ſupply, which, during life, we had accumulated from the general maſs.

CHAP.

CHAP. XX.

Of Winds, irregular and regular.

WIND is a current of air. Experimental philoſophers produce an artificial wind, by an inſtrument called an aeolipile. This is nothing more than an hollow copper ball, with a long pipe; a tea-kettle might be readily made into one, if it were entirely cloſed at the lid, and the ſpout left open; through this ſpout it is to be filled with water, and then ſet upon the fire, by which means it produces a violent blaſt, like wind, which continues while there is any water remaining in the inſtrument. In this manner water is converted into a ruſhing air; which, if caught as it goes out, and left to cool, is again quickly converted into its former element. Beſides this, as was mentioned in the former chapter, almoſt every ſubſtance contains ſome portions of air. Vegetables, or the bodies of animals left to putrefy, produce it in a very copious manner. But it is not only ſeen thus eſcaping from bodies, but it may be very eaſily made to enter into them. A quantity of air may be compreſſed into water, ſo as to be intimately blended with it. It finds a much eaſier admiſſion into wine, or any fermented

liquor; and an easier still, into spirits of wine. Some salts suck up the air in such quantities, that they are made sensibly heavier thereby, and often are melted by its moisture. In this manner, most bodies, being found either capable of receiving or affording it, we are not to be surprised at those streams of air that are continually fleeting round the globe. Minerals, vegetables, and animals, contribute to encrease the current; and are sending off their constant supplies. These, as they are differently affected by cold or heat, by mixture or putrefaction, all yield different quantities of air at different times; and the loudest tempests, and most rapid whirlwinds, are formed for their united contributions.

The sun is the principal instrument in rarefying the juices of plants, so as to give an escape to their imprisoned air; it is also equally operative in promoting the putrefaction of animals. Mineral exhalations are more frequently raised by subterranean heat. The moon, the other planets, the seasons, are all combined in producing these effects in a smaller degree. Mountains give a direction to the courses of the air. Fires carry a current of air along their body. Night and day alternately chill and warm the earth, and produce an alternate current of its vapours. These, and many other causes, may be as-

ſigned for the variety, and the activity of the winds, their continual change, and uncertain duration.

With us on land, as the wind proceeds from ſo many cauſes, and meets ſuch a variety of obſtacles, there can be but little hopes of ever bringing its motions to conform to theory; or of foretelling how it may blow a minute to come. The great Bacon, indeed, was of opinion, that by a cloſe and regular hiſtory of the winds, continued for a number of ages together, and the particulars of each obſervation reduced to general maxims, we might at laſt come to underſtand the variations of this capricious element; and that we could foretell the certainty of a wind, with as much eaſe as we now foretell the return of an eclipſe. Indeed, his own beginnings in this arduous undertaking, ſeem to ſpeak the poſſibility of it ſucceſs; but, unhappily for mankind, this inveſtigation is the work of ages, and we want a Bacon to direct the proceſs.

To be able, therefore, with any plauſibility, to account for the variations of the wind upon land, is not to be at preſent expected; and to underſtand any thing of their nature, we muſt have recourſe to thoſe places where they are more permanent and ſteady. This uniformity

and ſteadineſs we are chiefly to expect upon the ocean. There, where there is no variety of ſubſtances to furniſh the air with various and inconſtant ſupplies; where there are no mountains to direct the courſe of its current, but where all is extenſively uniform and even; in ſuch a place, the wind ariſing from a ſimple cauſe, muſt have but one ſimple motion. In fact, we find it ſo. There are many parts of the world where the winds, that with us are ſo uncertain, pay their ſtated viſits. In ſome places, they are found to blow one way by day, and another by night; in others, for one half of the year, they go in a direction contrary to their former courſe: but what is more extraordinary ſtill, there are ſome places where the winds never change, but for ever blow the ſame way. This is particularly found to obtain between the tropics in the Atlantic and Æthiopic oceans; as well as in the great Pacific ſea.

Few things can appear more extraordinary to a perſon who has never been out of our variable latitudes, than this ſteady wind, that for ever ſits in the ſail, ſending the veſſel forward; and as effectually preventing its return. He who has been taught to conſider that nothing in the world is ſo variable as the winds, muſt certainly be ſurpriſed to find a place where

there is nothing more uniform. With us their inconſtancy has become a proverb; with the natives of thoſe diſtant climates, they may talk of a friend or a miſtreſs as fixed and unchangeable as the winds, and mean a compliment by the compariſon. When our ſhips are once arrived into the proper latitudes of the great Pacific ocean, the mariner forgets the helm, and his ſkill becomes almoſt uſeleſs: neither ſtorms nor tempeſts are known to deform the glaſſy boſom of that immenſe ſheet of waters; a gentle breeze, that for ever blows in the ſame direction, reſts upon the canvas, and ſpeeds the navigator. In the ſpace of ſix weeks, ſhips are thus known to croſs an immenſe ocean, that takes more than ſo many months to return. Upon returning, the trade-wind, which has been propitious, is then avoided; the mariner is generally obliged to ſteer into the northern latitudes, and to take the advantage of every caſual wind that offers, to aſſiſt him into port. This wind, which blows with ſuch conſtancy one way, is known to prevail not only in the Pacific ocean, but alſo in the Atlantic, between the coaſts of Guinea and Brazil; and, likewiſe, in the Æthiopic ocean. This ſeems to be the great univerſal wind, blowing from the eaſt to the

weſt, that prevails in all the extenſive oceans, where the land does not frequently break the general current. Were the whole ſurface of the globe an ocean, there would probably be but this one wind, for ever blowing from the eaſt, and purſuing the motions of the ſun weſtward. All the other winds ſeem ſubordinate to this; and many of them are made from the deviations of its current. To form, therefore, any conception relative to the variations of the wind in general, it is proper to begin with that which never varies.

There have been many theories to explain this invariable motion of the winds; among the reſt, we cannot omit that of Doctor Lyſter, for its ſtrangeneſs: "The ſea," ſays he, "in thoſe latitudes, is generally covered over with green weeds, for a great extent; and the air produced from the vegetable perſpiration of theſe, produces the trade-wind." The theory of Carteſius was not quite ſo abſurd. He alledged, that the earth went round faſter than its atmoſphere at the equator; ſo that its motion, from weſt to eaſt, gave the atmoſphere an imaginary one from eaſt to weſt; and thus an eaſt wind was eternally ſeen to prevail. Rejecting thoſe arbitrary opinions, conceived without force, and aſſerted without proof, Doctor Halley has given

one more plausible; which seems to be the reigning system of the day.

To conceive his opinion clearly, let us for a moment suppose the whole surface of the earth to be an ocean, and the air encompassing it on every side, without motion. Now it is evident, that that part of the air which lies directly under the beams of the sun, will be rarified; and if the sun remained for ever in the same place, there would be a great vacuity in the air, if I may so express it, beneath the place where the sun stood. The sun moving forward, from east to west, this vacuity will follow too, and still be made under it. But while it goes on to make new vacuities, the air will rush in to fill up those the sun has already made; in other words, as it is still travelling forward, the air will continually be rushing in behind, and pursue its motions from east to west. In this manner, the air is put into motion by day; and by night, the parts continue to impel each other, till the next return of the sun, that gives a new force to the circulation.

In this manner is explained the constant east wind that is found blowing round the globe, near the equator. But it is also known, that as we recede from the equator on either side, we come into a trade-wind, that continually blows

from the poles, from the north on one ſide, or the ſouth on the other, both directing towards the equator. This alſo proceeds from a ſimilar cauſe with the former; for the air being more rarefied in thoſe places over which the ſun more directly darts its rays, the currents will come both from the north and the ſouth, to fill up the intermediate vacuity.

Theſe two motions, namely, the general one from eaſt to weſt, and the more particular one from both the poles, will account for all the phænomena of trade-winds; which, if the whole ſurface of the globe were ſea, would undoubtedly be conſtant, and for ever continue to blow in one direction. But there are a thouſand circumſtances to break theſe air-currents into ſmaller ones; to drive them back againſt their general courſe; to raiſe or depreſs them; to condenſe them into ſtorms; or to whirl them in eddies. In conſequence of this, regard muſt be often had to the nature of the ſoil, the poſition of the high mountains, the courſe of the rivers, and even to the luxuriance of vegetation.

If a country lying directly under the ſun, be very flat and ſandy, and if the land be low and extenſive, the heats occaſioned by the reflection of the ſun-beams, produces a very great rarefaction of the air. The deſarts of Africa, which

are conformable to this defcription, are fcarce ever fanned by a breath of wind by day; but the burning fun is continually feen blazing in intolerable fplendor above them. For this reafon, all along the coafts of Guinea, the wind is always perceived blowing in upon land, in order to fill up the vacuity caufed by the fun's operation. In thofe fhores, therefore, the wind blows in a contrary direction to that of its general current; and is conftantly found fetting in from the weft.

From the fame caufe it happens, that thofe conftant calms, attended with deluges of rain, are found in the fame part of the ocean. For this tract being placed in the middle, between the wefterly winds blowing on the coaft of Guinea, and the eafterly trade-winds that move at fome diftance from fhore, in a contrary direction, the tendency of that part of the air that lies between thefe two oppofite currents, is indifferent to either, and fo refts between both in torpid ferenity; and the weight of the incumbent atmofphere, being diminifhed by the continual contrary winds blowing from hence, it is unable to keep the vapours fufpended that are copioufly borne thither; fo that they fall in continual rains.

But it is not to be fuppofed, that any theory

can account for all the phænomena of even thoſe winds that are known to be moſt regular. Inſtead of a complete ſyſtem of the trade-winds, we muſt rather be content with an imperfect hiſtory. Theſe *, as was ſaid, being the reſult of a combination of effects, aſſume as great a variety as the cauſes producing them are various.

Beſides the great general wind above mentioned, in thoſe parts of the Atlantic that lie under the temperate zone, a north wind prevails conſtantly during the months of October, November, December, and January. Theſe, therefore, are the moſt favourable months for embarking for the Eaſt-Indies, in order to take the benefit of theſe winds, for croſſing the Line: and it has been often found, by experience, that thoſe who had ſet ſail five months before, were not in the leaſt farther advanced in their voyage, than thoſe who waited for the favourable wind. During the winter of Nova Zembla, and the other arctic countries, a north wind reigns almoſt continually. In the Cape de Verde iſlands, a ſouth wind prevails during the month of July. At the Cape of Good Hope, a north-weſt wind blows during the month of September. There are alſo regular winds, produced by various cauſes, upon land. The ancient Greeks were the

* Buffon, vol. ii. p. 230.

first who obferved a conftant breeze, produced by the melting of the fnows, in fome high neighbouring countries. This was perceived in Greece, Thrace, Macedonia, and the Ægean fea. The fame kind of winds are now remarked in the kingdom of Congo, and the moft fouthern parts of Africa. The flux and reflux of the fea alfo produces fome regular winds, that ferve the purpofes of trade; and, in general, it may be obferved, that wherever there is a ftrong current of water, there is a current of air that feems to attend it.

Befide thefe winds that are found to blow in one direction, there are, as was faid before, others that blow for certain months of the year one way, and the reft of the year the contrary way: thefe are called the Monfoons, from a famous pilot of that name, who firft ufed them in navigation with fuccefs*. In all that part of the ocean that lies between Africa and India, the eaft winds begin at the month of January, and continue till about the commencement of June. In the month of Auguft, or September, the contrary direction takes place; and the weft winds prevail for three or four months. The interval between thefe winds, that is to fay, from the end of June to the beginning of

* Varenii Geographia Generalis, cap. 20.

Auguſt, there is no fixed wind; but the ſea is uſually toſſed by violent tempeſts, proceeding from the north. Theſe winds are always ſubject to their greateſt variations, as they approach the land; ſo that on one ſide of the great peninſula of India, the coaſts are, for near half the year, harraſſed by violent hurricanes, and northern tempeſts; while, on the oppoſite ſide, and all along the coaſts of Coromandel, theſe dreadful tempeſts are wholly unknown. At Java, and Ceylon, a weſt wind begins to reign in the month of September; but at fifteen degrees of ſouth latitude, this wind is found to be loſt, and the great general trade wind from the eaſt, is perceived to prevail. On the contrary, at Cochin, in China, the weſt wind begins at March; ſo that theſe Monſoons prevail, at different ſeaſons, throughout the Indies. So that the mariner takes one part of the year to go from Java to the Moluccas; another from Cochin to Molucca; another from Molucca to China; and ſtill another to direct him from China to Japan.

There are winds alſo that may be conſidered as peculiar to certain coaſts; for example, the ſouth wind is almoſt conſtant upon the coaſts of Chili and Peru; weſtern winds almoſt conſtantly prevail on the coaſt of Terra Magellanica; and

in the environs of the Streights le Maire. On the coafts of Malabar, north and north-weft winds prevail continually; along the coaft of Guinea, the north-weft wind is alfo very frequent; and, at a diftance from the coafts, the north-eaft is always found prevailing. From the beginning of November to the end of December, a weft wind prevails on the coafts of Japan; and, during the whole winter, no fhips can leave the port of Cochin, on account of the impetuofity of the winds that fet upon the coaft. Thefe blow with fuch vehemence, that the ports are entirely choaked up with fand, and even boats are not able to enter. However, the eaft winds that prevail for the other half of the year, clear the mouths of their harbours from the accumulations of the preceding winter, and fet the confined fhips at liberty. At the Streights of Babelmandel there is a fouth wind that periodically returns, and which is always followed by a north-eaft.

Befides winds thus peculiar to certain coafts, there are others found to prevail on all the coafts, in warm climates; which, during one part of the day, blow from the fhore, and, during another part of it, blow from the fea. The fea breeze, in thofe countries, as Dampier

obſerves, commonly riſes in the morning, about nine, proceeding ſlowly, in a fine ſmall black curl, upon the ſurface of the water, and making its way to refreſh the ſhore. It is gentle at firſt, but encreaſes gradually till twelve, then inſenſibly ſinks away, and is totally huſhed at five. Upon its ceaſing, the land-breeze begins to take its turn, which encreaſes till twelve at night, and is ſucceeded, in the morning, by the ſea-breeze again. Without all doubt, nothing could have been more fortunate, for the inhabitants of the warm countries, where thoſe breezes blow, than this alternate refreſhment, which they feel at thoſe ſeaſons when it is moſt wanted. The heat, on ſome coaſts, would be inſupportable, were it not for ſuch a ſupply of air, when the ſun has rarefied all that which lay more immediately under the coaſt. The ſea-breeze temperates the heat of the ſun by day; and the land-breeze corrects the malignity of the dews, and vapours, by night. Where theſe breezes, therefore, prevail, and they are very common, the inhabitants enjoy a ſhare of health and happineſs, unknown to thoſe that live much farther up the country, or ſuch as live in ſimilar latitudes without this advantage. The cauſe of theſe obviouſly ſeems to ariſe from the rarefaction of

the air by the ſun, as their duration continues with its appearance, and alters when it goes down. The ſun, it is obſerved, equally diffuſing his beams upon land and ſea, the land, being a more ſolid body than the water, receives a greater quantity of heat, and reflects it more ſtrongly. Being thus, therefore, heated to a greater degree than the waters, it, of conſequence, drives the air from land out to ſea; but, its influence being removed, the air returns to fill up the former vacuity. Such is the uſual method of accounting for this phænomenon; but, unfortunately, theſe ſea and land breezes are viſitants that come at all hours. On the coaſts of Malabar *, the land-breezes begin at midnight, and continue till noon; then the ſea-breezes take their turn, and continue till midnight. While, again, at Congo, the land-breezes begin at five, and continue till nine the next day.

But, if the cauſe of theſe be ſo inſcrutable, that are, as we ſee, tolerably regular in their viſitations, what ſhall we ſay to the winds of our own climate, that are continually ſhifting, and incapable of reſt? Some general cauſes may be aſſigned, which nothing but particular experience can apply. And, in the firſt place, it

* Buffon, vol. ii. p. 252.

may be obferved, that clouds, and heat, and, in fhort, whatever either encreafes the denfity or the elafticity of the air, in any one place, will produce a wind there: for the encreafed activity of the air thus preffing more powerfully on the parts of it that are adjacent, will drive them forward; and thus go on, in a current, till the whole comes to an equality.

In this manner, as a denfer air produces a wind, on the one hand; fo will any accident, that contributes to lighten the air, produce it on the other: for, a lighter air may be confidered as a vacuity, into which the neighbouring air will rufh: and hence it happens, that when the barometer marks a peculiar lightnefs in the air, it is no wonder that it foretells a ftorm.

The winds upon large waters are generally more regular than thofe upon land. The wind at fea generally blows with an even fteady gale; the wind at land puffs by intervals, encreafing its ftrength, and remitting it, without any apparent caufe. This, in a great meafure, may be owing to the many mountains, towers, or trees, that it meets in its way, all contributing either to turn it from its courfe, or interrupt its paffage.

The

The eaſt wind blows more conſtantly than any other, and for an obvious reaſon: all other winds are, in ſome meaſure, deviations from it, and partly may owe their origin thereto. It is generally, likewiſe, the moſt powerful, and for the ſame reaſon.

There are often double currents of the air. While the wind blows one way, we frequently ſee the clouds move another. This is generally the caſe before thunder; for it is well known that the thunder cloud always moves againſt the wind: the cauſe of this ſurpriſing appearance has hitherto remained a ſecret. From hence we may conclude, that weathercocks only inform us of that current of the air, which is near the ſurface of the earth; but are often erroneous with regard to the upper regions; and, in fact, Derham has often found them erroneous.

Winds are generally more powerful on elevated ſituations than on the plain, becauſe their progreſs is interrupted by fewer obſtacles. In proportion as we aſcend the heights of a mountain, the violence of the weather ſeems to encreaſe, until we have got above the region of ſtorms, where all is uſually calm and ſerene. Sometimes, however, the ſtorms riſe even to the tops of the higheſt mountains; as we learn from thoſe who have been on the Andes, and

as we are convinced by the deep ſnows that crown even the higheſt.

Winds blowing from the ſea are generally moiſter, and more attended with rains, than thoſe which blow over extenſive tracts of land: for the ſea gives off more vapours to the air, and theſe are rolled forward upon land, by the winds blowing from thence *. For this reaſon our eaſterly winds, that blow from the continent, are dry, compared with thoſe that blow from the ſurface of the ocean, with which we are ſurrounded on every other quarter.

In general the winds are more boiſterous in ſpring and autumn, than at other ſeaſons: for, that being the time of high tides, the ſea may communicate a part of its motions to the winds. The ſun and moon, alſo, which then have a greater effect upon the waters, may alſo have ſome influence upon the winds; for, there being a great body of air ſurrounding the globe, which, if condenſed into water, would cover it to the depth of thirty-two feet, it is evident that the ſun and moon will, to a proportionable degree, affect the atmoſphere, and make a tide of air. This tide will be ſcarce perceivable, indeed; but, without doubt, it actually exiſts; and may contribute to encreaſe the

* Derham's Phyſico-Theol.

vernal and autumnal ſtorms, which are then known to prevail.

Upon narrowing the paſſage through which the air is driven, both the denſity and the ſwiftneſs of the wind is encreaſed. For as currents of water flow with greater force and rapidity by narrowing their channels, ſo alſo will a current of air, driven through a contracted ſpace, grow more violent and irreſiſtible. Hence we find thoſe dreadful ſtorms that prevail in the defiles of mountains, where the wind, puſhing from behind through a narrow channel, at once encreaſes in ſpeed and denſity, levelling, or tearing up, every obſtacle that riſes to obſtruct its paſſage.

Winds reflected from the ſides of mountains and towers, are often found to be more forceful than thoſe in direct progreſſion. This we frequently perceive near lofty buildings, ſuch as churches or ſteeples, where winds are generally known to prevail, and that much more powerful than at ſome diſtance. The air, in this caſe, by ſtriking againſt the ſide of the building, acquires additional denſity, and therefore blows with more force.

Theſe differing degrees of denſity, which the air is found to poſſeſs, ſufficiently ſhew that the force of the winds do not depend upon their velo-

city alone; ſo that thoſe inſtruments called *anemometers*, which are made to meaſure the velocity of the wind, will by no means give us certain information of the force of the ſtorm. In order to eſtimate this with exactneſs, we ought to know its denſity; which alſo theſe are not calculated to diſcover. For this reaſon we often ſee ſtorms, with very powerful effects, that do not ſeem to ſhew any great ſpeed; and, on the contrary, we ſee theſe wind meaſurers go round, with great ſwiftneſs, when ſcarce any damage has followed from the ſtorm.

Such is the nature, and the inconſtancy, of the irregular winds with which we are beſt acquainted. But their effects are much more formidable in thoſe climates, near the tropics, where they are often found to break in upon the ſteady courſe of the trade-winds, and to mark their paſſage with deſtruction. With us the tempeſt is but rarely known, and its ravages are regiſtered as an uncommon calamity; but, in the countries that lie between the tropics, and for a good ſpace beyond them, its viſits are frequent, and its effects anticipated. In theſe regions the winds vary their terrors; ſometimes involving all things in a ſuffocating heat; ſometimes mixing all the elements of fire, air, earth, and water together; ſometimes, with a momentary ſwiftneſs, paſſing over the face

of the country, and deſtroying all things in their paſſage; and ſometimes raiſing whole ſandy deſerts in one country, to depoſit them upon ſome other. We have little reaſon, therefore, to envy theſe climates the luxuriance of their ſoil, or the brightneſs of their ſkies. Our own muddy atmoſphere, that wraps us round in obſcurity, though it fails to gild our proſpects with ſun-ſhine, or our groves with fruitage, nevertheleſs anſwers the calls of induſtry. They may boaſt of a plentiful, but precarious harveſt; while, with us, the labourer toils in a certain expectation of a moderate, but an happy return.

In Egypt *, a kingdom ſo noted for its fertility, and the brightneſs of its atmoſphere, during ſummer, the ſouth winds are ſo hot, that they almoſt ſtop reſpiration; beſides which, they are charged with ſuch quantities of ſand, that they ſometimes darken the air, as with a thick cloud. Theſe ſands are ſo fine, and driven with ſuch violence, that they penetrate every where; even into cheſts, be they ſhut never ſo cloſely. If theſe winds happen to continue for any length of time, they produce epidemic diſeaſes; and are often followed by a great mortality. It is alſo found to rain but very ſeldom in that country; however, the want of ſhowers

* Buffon, vol. ii. p. 258.

is richly compenſated by the copiouſneſs of their dews, which greatly tend to promote vegetation.

In Perſia, the winter begins in November, and continues till March. The cold at that time is intenſe enough to congeal the water; and ſnow falls in abundance upon their mountains. During the months of March and April, winds ariſe, that blow with great force, and ſeem to uſher in the heats of ſummer. Theſe return again, in autumn, with ſome violence; without, however, producing any dreadful effects. But, during their ſummer, all along the coaſts of the Perſian Gulph, a very dangerous wind prevails, which the natives call the Sameyel, ſtill more dreadful and burning than that of Egypt, and attended with inſtant and fatal effects. This terrible blaſt, which was, perhaps, the peſtilence of the ancients, inſtantly kills all thoſe that it involves in its paſſage. What its malignity conſiſts in, none can tell, as none have ever ſurvived its effects, to give information. It frequently, as I am told, aſſumes a viſible form; and darts, in a kind of bluiſh vapour, along the ſurface of the country. The natives, not only of Perſia, but Arabia, talk of its effects with terror; and their poets have not failed to heighten them, with the aſſiſtance of imagination. They have deſcribed it as un-

der the conduct of a miniſter of vengeance, who governs its terrors, and raiſes, or depreſſes it, as he thinks proper *. Theſe deadly winds are alſo known along the coaſts of India, at Necapatan, Maſulipatan, and Petapoli. But, luckily for mankind, the ſhortneſs of their duration diminiſhes the injuries that might enſue from their malignity.

The Cape of Good Hope, as well as many iſlands in the Weſt-Indies, are famous for their hurricanes, and that extraordinary kind of cloud which is ſaid to produce them. This cloud, which is the fore-runner of an approaching hurricane, appears, when firſt ſeen, like a ſmall black ſpot, on the verge of the horizon; and is called, by ſailors, the bull's eye, from being ſeen ſo minute at a vaſt diſtance. All this time, a perfect calm reigns over the ſea and land, while the cloud grows gradually broader as it approaches. At length, coming to the place where its fury is to fall, it inveſts the whole horizon with darkneſs. During all the time of its approach, an hollow murmur is heard in the cavities of the mountains; and beaſts and animals, ſenſible of its approach, are ſeen running over the fields, to ſeek for ſhelter. Nothing can be more terrible than its violence when it begins. The houſes in thoſe countries,

* Herbelot. Bibliotheque Oriental.

which are made of timber, the better to resist its fury; bend to the blast like osiers, and again recover their rectitude. The sun, which, but a moment before, blazed with meridian splendor, is totally shut out; and a midnight darkness prevails, except that the air is incessantly illuminated with gleams of lightning, by which one can easily see to read. The rain falls, at the same time, in torrents; and its descent has been resembled to what pours from the spouts of our houses after a violent shower. These hurricanes are not less offensive to the sense of smelling also; and never come without leaving the most noisome stench behind them. If the seamen also lay by their wet cloaths, for twenty-four hours, they are all found swarming with little white maggots, that were brought with the hurricane. Our first mariners, when they visited these regions, were ignorant of its effects, and the signs of its approach; their ships, therefore, were dashed to the bottom at the first onset; and numberless were the wrecks which the hurricane occasioned. But, at present, being forewarned of its approach, they strip their masts of all their sails, and thus patiently abide its fury. These hurricanes are common in all the tropical climates. On the coasts of Guinea they have frequently three or four in a day, that thus shut out the heavens, for a little space;

and when past leave all again in former splendor. They chiefly prevail, on that coast, in the intervals of the trade-winds; the approach of which clears the air of its meteors, and gives these mortal showers that little degree of wholesomeness, which they possess. They chiefly obtain there during the months of April and May; they are known, at Loango, from January to April; on the opposite coast of Africa, the hurricane season begins at May; and, in general, whenever a trade-wind begins to cease, these irregular tempests are found to exert their fury.

All this is terrible; but there is a tempest, known in those climates, more formidable than any we have hitherto been describing, which is called, by the Spaniards, a Tornado. As the former was seen arriving from one part of the heavens, and making a line of destruction; so the winds in this seem to blow from every quarter, and settle upon one destined place, with such fury, that nothing can resist their vehemence. When they have all met, in their central spot, then the whirlwind begins with circular rapidity. The sphere every moment widens as it continues to turn, and catches every object that lies within its attraction. This, also, like the former, is preceded by a flattering calm; the air is every where hushed; and the sea is as

ſmooth as poliſhed glaſs: however, as its effects are more dreadful than thoſe of the ordinary hurricane, the mariner tries all the power of his ſkill to avoid it; which, if he fails of doing, there is the greateſt danger of his going to the bottom. All along the coaſts of Guinea, beginning about two degrees north of the line, and ſo downward, lengthwiſe, for about a thouſand miles, and as many broad, the ocean is unnavigable, upon account of theſe tornados. In this torpid region there reigns unceaſing tornados, or continual calms; among which, whatever ſhip is ſo unhappy as to fall, is totally deprived of all power of eſcaping. In this dreadful repoſe of all the elements, the ſolitary veſſel is obliged to continue, without a ſingle breeze to aſſiſt the mariner's wiſhes, except thoſe whirlwinds, which only ſerve to encreaſe his calamity. At preſent, therefore, this part of the ocean is totally avoided; and, although there may be much gold along the coaſts of that part of Africa, to tempt avarice, yet there is ſomething, much more dreadful than the fabled dragon of antiquity, to guard the treaſure. As the internal parts of that country are totally unknown to travellers, from their burning ſand and extenſive deſarts, ſo here we find a vaſt tract of ocean, lying off its ſhores, equally unviſited by the mariner.

But of all these terrible tempests that deform the face of Nature, and repress human presumption, the sandy tempests of Arabia and Africa, are the most terrible, and strike the imagination most strongly. To conceive a proper idea of these, we are by no means to suppose them resembling those whirlwinds of dust that we sometimes see scattering in our air, and sprinkling their contents upon our roads, or meadows. The sand-storm of Africa exhibits a very different appearance. As the sand of which the whirlwind is composed is excessively fine, and almost resembles the parts of water, its motion entirely resembles that of a fluid; and the whole plain seems to float onward, like a slow inundation. The body of sand thus rolling, is deep enough to bury houses and palaces in its bosom: travellers who are crossing those extensive desarts, perceive its approach at a distance; and, in general, have time to avoid it, or turn out of its way, as it generally extends but to a moderate breadth. However, when it is extremely rapid, or very extensive, as sometimes is the case, no swiftness, no art, can avail; nothing then remains, but to meet death with fortitude, and submit to be buried alive with resignation.

It is happy for us of Britain, that we have no ſuch calamity to fear; for, from this, even ſome parts of Europe are not entirely free. We have an account given us, in the Hiſtory of the French Academy, of a miſerable town in France, that is conſtantly in danger of being buried under a ſimilar inundation; with which I will take leave to cloſe this chapter. "In the neighbourhood of St. Paul de Leon, in Lower Brittany*, there lies a tract of country along the ſea-ſide, which before the year 1666 was inhabited, but now lies deſerted, by reaſon of the ſands which cover it, to the height of twenty feet; and which every year advance more and more in land, and gain ground continually. From the time mentioned above, the ſand has buried more than ſix leagues of the country inward; and it is now but half a league from the town of St. Paul; ſo that, in all appearance, the inhabitants muſt be obliged to abandon it entirely. In the country that has been overwhelmed, there are ſtill to be ſeen the tops of ſome ſteeples peeping through the ſand, and many chimnies that ſtill remain above this ſandy ocean. The inhabitants, however, had ſufficient time to eſcape; but being deprived of their little all, they had no other re-

* Hiſtoire de l'Académie des Sciences, an. 1722.

ſource but begging for their ſubſiſtence. This calamity chiefly owes its advancement to a north, or an eaſt wind, raiſing the ſand, which is extremely fine, in ſuch great quantities, and with ſuch velocity, that M. Deſlands, who gave the account, ſays, that while he was walking near the place, during a moderate breeze of wind, he was obliged, from time to time, to ſhake the ſand from his cloaths and his hat, on which it was lodged in great quantities, and made them too heavy to be eaſily borne. Still further, when the wind was violent, it drove the ſand acroſs a little arm of the ſea, into the town of Roſcoff, and covered the ſtreets of that place two feet deep; ſo that they have been obliged to carry it off in carts. It may alſo be obſerved, that there are ſeveral particles of iron mixed with the ſand, which are readily affected by the loadſtone. The part of the coaſt that furniſhes theſe ſands, is a tract of about four leagues in length; and is upon a level with the ſea at high-water. The ſhore lies in ſuch a manner as to leave its ſands ſubject only to the north and eaſt winds, that bear them farther up the ſhore. It is eaſy to conceive how the ſame ſand that has at one time been borne a ſhort way in land, may, by ſome ſucceeding and ſtronger

blaſt, be carried up much higher; and thus the whole may continue advancing forward, deluging the plain, and totally deſtroying its fertility. At the ſame time, the ſea, from whence this deluge of ſand proceeds, may furniſh it in inexhauſtible quantities. This unhappy country, thus overwhelmed in ſo ſingular a manner, may well juſtify what the ancients and the moderns have reported concerning thoſe tempeſts of ſand in Africa, that are ſaid to deſtroy villages, and even armies in their boſom."

C H A P. XXI.

Of Meteors, and ſuch Appearances as reſult from a Combination of the Elements.

IN proportion as the ſubſtances of nature are more compounded and combined, their appearances become more inexplicable and amazing. The properties of water have been very nearly aſcertained. Many of the qualities of air, earth, and fire, have been diſcovered, and eſtimated; but when theſe come to be united by Nature, they often produce a reſult which no artificial combinations can imitate: and weſt and ſurpriſed, that although we are poſſeſſed of all thoſe ſubſtances which Nature makes uſe of,

she shews herself a much more various operator than the most skilful chemist ever appeared to be. Every cloud that moves, and every shower that falls, serves to mortify the philosopher's pride, and to shew him hidden qualities in air and water, that he finds it difficult to explain. Dews, hail, snow, and thunder, are not less difficult for being more common. Indeed, when we reflect on the manner in which Nature performs any one of these operations, our wonder encreases. To see water, which is heavier than air, rising in air, and then falling in a form so very different from that in which it rose; to see the same fluid at one time descending in the form of hail, at another in that of snow; to see two clouds, by dashing against each other, producing an electrical fire, which no watery composition that we know of can effect; these, I say, serve sufficiently to excite our wonder; and still the more, in proportion as the objects are ever pressing on our curiosity. Much, however, has been written concerning the manner in which nature operates in these productions; as nothing is so ungrateful to mankind as hopeless ignorance.

And first, with regard to the manner in which water evaporates, and rises to form clouds, much has been advanced, and many theories de-

vised. All water*, say some, has a quantity of air mixed with it; and the heat of the sun darting down, disengages the particles of this air from the grosser fluid: the sun's rays being reflected back from the water, carry back with them those bubbles of air and water which, being lighter than the condensed air, will ascend till they meet with a more rarefied air; and they will then stand suspended. Experience, however proves nothing of all this. Particles of air or fire, are not thus known to ascend with a thin coat of water; and, in fact, we know that the little particles of steam are solid drops of water. But besides this, water is known to evaporate more powerfully in the severest frost, than when the air is moderately warm†. Doctor Hamilton, therefore, of the university of Dublin, rejecting this theory, has endeavoured to establish another. According to him, as aqua fortis is a menstruum that dissolves iron, and keeps it mixed in the fluid; as aqua regia is a menstruum that dissolves gold; or as water dissolves salts to a certain quantity; so air is a menstruum that corrodes and dissolves a certain quantity of water, and keeps it suspended above. But however ingenious this may be, it can hardly be

* Spectacle de la Nature, vol. iii.

† Memoires de l'Académie des Sciences, an. 1705.

admitted;

admitted; as we know, by Mariotte's experiment*, that if water and air be enclosed together, instead of the air's acting as a menstruum upon the water, the water will act as a menstruum upon the air, and take it all up. We know also, that of two bodies, that which is most fluid and penetrating, is most likely to be the menstruum of the other; but water is more fluid and penetrating than air, and, therefore, the most likely of the two to be the menstruum. We know that all bodies are more speedily acted upon, the more their parts are brought into contact with the menstruum that dissolves them: but water, inclosed with comprest air, is not the more diminished thereby †. In short, we know, that cold, which diminishes the force of other menstruums, is often found to promote evaporation. In this variety of opinion, and uncertainty of conjecture, I cannot avoid thinking that a theory of evaporation may be formed upon very simple and obvious principles, and embarrassed, as far as I can conceive, with very few objections.

We know that a repelling power prevails in nature, not less than an attractive one. This repulsion prevails strongly between the body of

* Mariotte, de la Nature de l'Air, p. 97, 106.

† See Boyle's Works, vol. ii. p. 619.

fire and that of water. If I plunge the end of a red hot bar of iron into a veſſel of water, the fluid riſes, and large drops of it fly up in all manner of directions, every part bubbling and ſteaming until the iron be cold. Why may we not, for a moment, compare the rays of the ſun, darted directly upon the ſurface of the water, to ſo many bars of red hot iron; each bar, indeed, infinitely ſmall, but not the leſs powerful? In this caſe, wherever a ray of fire darts, the water, from its repulſive quality, will be driven on all ſides; and, of conſequence, as in the caſe of the bar of iron, a part of it will riſe. The parts thus riſing, however, will be extremely ſmall; as the ray that darts is extremely ſo. The aſſemblage of the rays darting upon the water in this manner, will cauſe it to riſe in a light thin ſteam above the ſurface; and as the parts of this ſteam are extremely minute, they will be lighter than air, and, conſequently, float upon it. There is no need for ſuppoſing them bubbles of water, filled with fire; for any ſubſtance, even gold itſelf, will float on air, if its parts be made ſmall enough; or, in other words, if its ſurface be ſufficiently encreaſed. This water, thus diſengaged from the general maſs, will be ſtill farther attenuated and broken by the reflected rays, and conſequently more adapted for aſcending.

From this plain account, every appearance in evaporation may be eafily deduced. The quantity of heat encreafes evaporation, becaufe it raifes a greater quantity of fteam. The quantity of wind encreafes evaporation; for, by waving the furface of the water, it thus expofes a greater furface to the evaporating rays. A dry froft, in fome meafure, affifts the quantity of evaporation; as the quantity of rays are found to be no way diminifhed thereby. Moift weather alone prevents evaporation; for the rays being abforbed, refracted, and broken, by the intervening moifture, before they arrive at the furface, cannot produce the effect; and the vapour will rife in a fmall proportion.

Thus far we have accounted for the afcent of vapours; but to account for their falling again, is attended with rather more difficulty. We have already obferved, that the particles of vapour, difengaged from the furface of the water, will be broken and attenuated in their afcent, by the reflected, and even the direct rays, that happen to ftrike upon their minute furfaces. They will, therefore, continue to afcend, till they rife above the operation of the reflected rays, which reaches but to a certain height above the furface of the earth. Being arrived at this

region, which is cold for want of reflected heat, they will be condenſed, and ſuſpended in the form of clouds. Some vapours that aſcend to great heights, will be frozen into ſnow; others, that are condenſed lower down, will put on the appearance of a miſt, which we find the clouds to be, when we aſcend among them, as they hang along the ſides of a mountain. Theſe clouds of ſnow and rain, being blown about by winds, are either entirely ſcattered and diſperſed above, or they are ſtill more condenſed by motion, like a ſnow-ball, that grows more large and ſolid as it continues to roll. At laſt, therefore, they will become too weighty for the air which firſt raiſed them, to ſuſtain; and they will deſcend, with their exceſs of weight, either in ſnow or rain. But as they will fall precipitately, when they begin to deſcend, the air, in ſome meaſure, will reſiſt the falling; for, as the deſcending fluid gathers velocity in its precipitation, the air will encreaſe its reſiſtance to it, and the water will, therefore, be thus broken into rain; as we ſee, that water which falls from the tops of houſes, though it begins in a ſpout, ſeparates into drops before it has got to the bottom. Were it not for this happy interpoſition of the air, between us and the water falling from a conſiderable

height above us, a drop of rain might fall with dangerous force, and an hail-ſtone might ſtrike us with fatal rapidity.

In this manner, evaporation is produced by day; but when the ſun goes down, a part of that vapour which his rays had excited, being no longer broken, and attenuated by the reflecting rays, it will become heavier than the air, even before it has reached the clouds; and it will, therefore, fall back in dews, which differ only from rain in deſcending before they have had time to condenſe into a viſible form.

Hail, the Carteſians ſay, is a frozen cloud, half melted, and frozen again in its deſcent. An hoar-froſt is but a frozen dew. Lightning we know to be an electrical flaſh, produced by the oppoſition of two clouds: and thunder to be the ſound proceeding from the ſame, continued by an echo reverberated among them. It would be to very little purpoſe, to attempt explaining exactly how theſe wonders are effected: we have as yet but little inſight into the manner in which theſe meteors are found to operate upon each other; and, therefore, we muſt be contented with a detail rather of their effects than their cauſes.

In our own gentle climate, where Nature wears the mildeſt and kindeſt aſpect, every me-

teor ſeems to befriend us. With us, rains fall in refreſhing ſhowers, to enliven our fields, and to paint the landſcape with a more vivid beauty. Snows cover the earth, to preſerve its tender vegetables from the inclemency of the departing winter. The dews deſcend with ſuch an imperceptible fall as no way injures the conſtitution. Even thunder is ſeldom injurious; and it is often wiſhed by the huſbandman, to clear the air, and to kill numberleſs inſects that are noxious to vegetation. Hail is the moſt injurious meteor that is known in our climate; but it ſeldom viſits us with violence, and then its fury is but tranſient.

One of the moſt dreadful ſtorms we hear of*, was that of Hertfordſhire, in the year 1697. It began by thunder and lightning, which continued for ſome hours, when ſuddenly a black cloud came forward, againſt the wind, and marked its paſſage with devaſtation. The hailſtones which it poured down, being meaſured, were found to be many of them fourteen inches round, and, conſequently, as large as a bowling-green ball. Wherever it came, every plantation fell before it; it tore up the ground, ſplit great oaks, and other trees, without number; the fields of rye were cut down, as if levelled with

‡ Phil. Tranſ. vol. ii. p. 147.

a ſcythe; wheat, oats, and barley, ſuffered the ſame damage. The inhabitants found but a precarious ſhelter, even in their houſes, their tiles and windows being broke by the violence of the hail-ſtones, which, by the force with which they came, ſeemed to have deſcended from a great height. The birds, in this univerſal wreck, vainly tried to eſcape by flight; pigeons, crows, rooks, and many more of the ſmaller and feebler kinds, were brought down. An unhappy young man, who had not time to take ſhelter, was killed; one of his eyes was ſtruck out of his head, and his body was all over black with the bruiſes: another had juſt time to eſcape, but not without the moſt imminent danger, his body being bruiſed all over. But what is moſt extraordinary, all this fell within the compaſs of a mile.

Mezeray, in his Hiſtory of France, tells us of a ſhower of hail much more terrible, which happened in the year 1510, when the French monarch invaded Italy. There was, for a time, an horrid darkneſs, thicker than that of midnight, which continued till the terrors of mankind were changed to ſtill more terrible objects, by thunder and lightning breaking the gloom, and bringing on ſuch a ſhower of hail, as no hiſtory of human calamities could equal.

These hail-ſtones were of a bluiſh colour; and ſome of them weighed not leſs than an hundred pounds. A noiſome vapour of ſulphur attended the ſtorm. All the birds and beaſts of the country were entirely deſtroyed. Numbers of the human race ſuffered the ſame fate. But what is ſtill more extraordinary, the fiſhes found no protection from their native element; but were equal ſufferers in the general calamity.

These, however, are terrors that are ſeldom exerted in our mild climates. They only ſerve to mark the page of hiſtory with wonder; and ſtand as admonitions to mankind, of the various ſtores of puniſhment in the hands of the Deity, which his power can treaſure up, and his mercy can ſuſpend.

In the temperate zones, therefore, meteors are rarely found thus terrible; but between the tropics, and near the poles, they aſſume very dreadful and various appearances. In thoſe inclement regions, where cold and heat exert their chief power, meteors ſeem peculiarly to have fixed their reſidence. They are ſeen there in a thouſand terrifying forms, aſtoniſhing to Europeans, yet diſregarded by the natives, from their frequency. The wonders of air, fire, and water, are there combined, to produce the moſt

tremendous effects; and to ſport with the labours and apprehenſions of mankind. Lightnings, that flaſh without noiſe; hurricanes, that tear up the earth; clouds, that all at once pour down their contents, and produce an inſtant deluge; mock ſuns, northern lights, that illuminate half the hemiſphere; circular rainbows; halos; fleeting balls of fire; clouds, reflecting back the images of things on earth, like mirrors; and water-ſpouts, that burſt from the ſea, to join with the miſts that hang immediately above them. Theſe are but a part of the phænomena that are common in thoſe countries; and from many of which, our own climate is, in a great meaſure, exempted.

The meteors of the torrid zone are different from thoſe that are found near the polar circles: and it may readily be ſuppoſed, that in thoſe countries where the ſun exerts the greateſt force in raiſing vapours of all kinds, there ſhould be the greateſt quantity of meteors. Upon the approach of the winter months, as they are called, under the line, which uſually begin about May, the ſky, from a fiery brightneſs, begins to be overcaſt, and the whole horizon ſeems wrapt in a muddy cloud. Miſts and vapours ſtill continue to riſe; and the air, which ſo lately before was clear and elaſtic, now

becomes humid, obſcure, and ſtifling: the fogs become ſo thick, that the light of the ſun ſeems in a manner excluded; nor would its preſence be known, but for the intenſe and ſuffocating heat of its beams, which dart through the gloom, and, inſtead of diſſipating, only ſerve to encreaſe the miſt. After this preparation, there follows an almoſt continual ſucceſſion of thunder, rain, and tempeſts. During this dreadful ſeaſon, the ſtreets of cities flow like rivers; and the whole country wears the appearance of an ocean. The inhabitants often make uſe of this opportunity to lay in a ſtock of freſh water, for the reſt of the year; as the ſame cauſe which pours down the deluge at one ſeaſon, denies the kindly ſhower at another. The thunder which attends the fall of theſe rains, is much more terrible than that we are generally acquainted with. With us, the flaſh is ſeen at ſome diſtance, and the noiſe ſhortly after enſues; our thunder generally rolls on one quarter of the ſky, and one ſtroke purſues another. But here it is otherwiſe; the whole ſky ſeems illuminated with unremitted flaſhes of lightning; every part of the air ſeems productive of its own thunders; and every cloud produces its own ſhock. The ſtrokes come ſo thick, that the inhabitants can ſcarce mark the intervals; but all is one unre-

mitted roar of elementary confusion. It should seem, however, that the lightning of those countries is not so fatal, or so dangerous, as with us; since, in this case, the torrid zone would be uninhabitable.

When these terrors have ceased, with which, however, the natives are familiar, meteors of another kind begin to make their appearance. The intense beams of the sun, darting upon stagnant waters, that generally cover the surface of the country, raise vapours of various kinds. Floating bodies of fire, which assume different names, rather from their accidental forms, than from any real difference between them, are seen without surprize. The draco volans, or flying dragon, as it is called; the ignis fatuus, or wandering fire; the fires of St. Helmo, or the mariner's light, are every where frequent; and of these we have numberless descriptions. "As I was riding in Jamaica," says Mr. Barbham, "one morning from my habitation, situated about three miles north-west from Jago de la Vega, I saw a ball of fire, appearing to me of the bigness of a bomb, swiftly falling down with a great blaze. At first I thought it fell into the town; but when I came nearer, I saw many people gathered together, a little to the southward, in the Sa-

vannah, to whom I rode up, to enquire the cause of their meeting: they were admiring, as I found, the ground's being ſtrangely broke up and ploughed by a ball of fire; which, as they ſaid, fell down there. I obſerved there were many holes in the ground; one in the middle of the bigneſs of a man's head, and five or ſix ſmaller round about it, of the bigneſs of one's fiſt, and ſo deep as not to be fathomed by ſuch implements as were at hand. It was obſerved, alſo, that all the green herbage was burnt up, near the holes; and there continued a ſtrong ſmell of ſulphur near the place, for ſome time after."

Ulloa gives an account of one of a ſimilar kind, at Quito *. "About nine at night," ſays he, "a globe of fire appeared to riſe from the ſide of the mountain Pichinca, and ſo large, that it ſpread a light over all the part of the city facing that mountain. The houſe where I lodged looking that way, I was ſurpriſed with an extraordinary light, darting through the crevices of the window-ſhutters. On this appearance, and the buſtle of the people in the ſtreet, I haſtened to the window, and came time enough to ſee it, in the middle of its career; which continued from weſt to ſouth, till

* Ulloa, vol. i. p. 41.

I lost sight of it, being intercepted by a mountain, that lay between me and it. It was round; and its apparent diameter about a foot. I observed it to rise from the sides of Pichinca; although, to judge from its course, it was behind that mountain where this congeries of inflammable matter was kindled. In the first half of its visible course it emitted a prodigious effulgence, then it began gradually to grow dim; so that, upon its disappearing behind the intervening mountain, its light was very faint."

Meteors, of this kind, are very frequently seen between the tropics; but they sometimes, also, visit the more temperate regions of Europe. We have the description of a very extraordinary one, given us by Montanari, that serves to shew to what great heights, in our atmosphere, these vapours are found to ascend. In the year 1676, a great globe of fire was seen at Bononia, in Italy, about three quarters of an hour after sun-set. It passed westward, with a most rapid course, and at the rate of not less than a hundred and sixty miles in a minute, which is much swifter than the force of a cannon-ball, and, at last, stood over the Adriatic sea. In its course it crossed over all Italy; and, by computation, it could not have been less than thirty-eight miles above the surface of the

earth. In the whole line of its courſe, wherever it approached, the inhabitants below could diſtinctly hear it, with a hiſſing noiſe, reſembling that of a fire-work. Having paſſed away to ſea, towards Corſica, it was heard, at laſt, to go off with a moſt violent exploſion, much louder than that of a cannon; and, immediately after, another noiſe was heard, like the rattling of a great cart upon a ſtony pavement; which was, probably, nothing more than the echo of the former ſound. Its magnitude, when at Bononia, appeared twice as long as the moon, one way; and as broad the other; ſo that, conſidering its height, it could not have been leſs than a mile long, and half a mile broad. From the height at which this was ſeen, and there being no volcano, on that quarter of the world, from whence it came, it is more than probable that this terrible globe was kindled on ſome part of the contrary ſide of the globe, in thoſe regions of vapours, which we have been juſt deſcribing; and thus, riſing above the air, and paſſing, in a courſe oppoſite to that of the earth's motion, in this manner it acquired its amazing rapidity.

To theſe meteors, common enough ſouthward, we will add one more of a very uncommon kind, which was ſeen, by Ulloa, at Quito, in Peru; the beauty of which will, in ſome meaſure,

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ferve to relive us, after the defcription of thofe hideous ones preceding. "At day-break," fays he, "the whole mountain of Pambamarca, where we then refided, was encompaffed with very thick clouds; which the rifing of the fun difperfed fo far, as to leave only fome vapours, too fine to be feen. On the fide oppofite to the rifing fun, and about ten fathoms diftant from the place where we were ftanding, we faw, as in a looking-glafs, each his own image; the head being, as it were, the center of three circular rainbows, one without the other, and juft near enough to each other as that the colours of the internal verged upon thofe more external; while round all was a circle of white, but with a greater fpace between. In this manner thefe circles were erected, like a mirror, before us; and as we moved, they moved, in difpofition and order. But, what is moft remarkable, though we were fix in number, every one faw the phenomenon, with regard to himfelf, and not that relating to others. The diameter of the arches gradually altered, as the fun rofe above the horizon; and the whole, after continuing a long time, infenfibly faded away. In the beginning, the diameter of the inward iris, taken from its laft colour, was about five degrees and a half; and that of the white arch,

which ſurrounded the reſt, was not leſs than ſixty-ſeven degrees. At the beginning of the phænomenon, the arches ſeemed of an oval or eliptical figure, like the diſk of the ſun; and afterwards became perfectly circular. Each of theſe was of a red colour, bordered with an orange; and the laſt bordered by a bright yellow, which altered into a ſtraw colour, and this turned to a green; but, in all, the external colour remained red." Such is the deſcription of one of the moſt beautiful illuſions that has been ever ſeen in nature. This alone ſeems to have combined all the ſplendours of optics in one view. To underſtand the manner, therefore, how this phænomenon was produced, would require a perfect knowledge of optics; which it is not our preſent province to enter upon. It will be ſufficient, therefore, only to obſerve, that all theſe appearances ariſe from the denſity of the cloud, together with its uncommon and peculiar ſituation, with reſpect to the ſpectator and the ſun. It may be obſerved, that but one of theſe three rainbows was real, the reſt being only reflections thereof. It may alſo be obſerved, that whenever the ſpectator ſtands between the ſun and a cloud of falling rain, a rainbow is ſeen, which is nothing more than the reflection of the different

ferent coloured rays of light from the bosom of the cloud. If, for instance, we take a glass globe, filled with water, and hang it up before us, opposite the sun, in many situations, it will appear transparent; but if it is raised higher, or sideways, to an angle of forty-five degrees, it will at first appear red; altered a very little higher, yellow; then green, then blue, then violet colour; in short, it will assume successively all the colours of the rainbow; but, if raised higher, still it will become transparent again. A falling shower may be considered as an infinite number of these little transparent globes, assuming different colours, by being placed at the proper heights. The rest of the shower will appear transparent, and no part of it will seem coloured; but such as are at angles of forty-five degrees from the eye, forty-five degrees upward, forty-five degrees on each side, and forty-five degrees downward, did not the plain of the earth prevent us. We, therefore, see only an arch of the rainbow, the lower part being cut off from our sight by the earth's interposition. However, upon the tops of very high mountains, circular rainbows are seen, because we can see to an angle of forty-five degrees downward, as well as upward, or sideways, and therefore we take in the rainbow's complete circle.

In thoſe forlorn regions, round the poles, the meteors, though of another kind, are not leſs numerous and alarming. When the winter begins, and the cold prepares to ſet in, the ſame miſty appearance which is produced in the ſouthern climates by the heat, is there produced by the contrary extreme *. The ſea ſmokes like an oven, and a fog ariſes, which mariners call the froſt ſmoke. This cutting miſt, commonly raiſes bliſters on ſeveral parts of the body; and, as ſoon as it is wafted to ſome colder part of the atmoſphere, it freezes to little icy particles, which are driven by the wind, and create ſuch an intenſe cold on land, that the limbs of the inhabitants are ſometimes frozen, and drop off.

There alſo, halos, or luminous circles round the moon, are oftener ſeen than in any other part of the earth, being formed by the froſt ſmoke; although the air otherwiſe ſeems to be clear. A lunar rainbow alſo is often ſeen there, though ſomewhat different from that which is common with us; as it appears of a pale white, ſtriped with grey. In theſe countries alſo the aurora borealis ſtreams, with peculiar luſtre, and variety of colours. In Greenland it generally ariſes in the eaſt, and darts its ſportive

* Paul Egede's Hiſtory of Greenland.

fires, with variegated beauty, over the whole horizon. Its appearance is almoſt conſtant in winter; and, at thoſe ſeaſons when the ſun departs, to return no more for half a year, this meteor kindly riſes to ſupply its beams, and affords ſufficient light for all the purpoſes of exiſtence. However, in the very midſt of their tedious night, the inhabitants are not entirely forſaken. The tops of the mountains are often ſeen painted with the red rays of the ſun; and the poor Greenlander from thence begins to date his chronology. It would appear whimſical to read a Greenland calendar, in which we might be told, that one of their chiefs, having lived forty days, died, at laſt, of a good old age; and that his widow continued for half a day to deplore his loſs, with great fidelity, before ſhe admitted a ſecond huſband.

The meteors of the day, in theſe countries, are not leſs extraordinary than thoſe of the night: mock ſuns are often reflected upon an oppoſite cloud; and the ignorant ſpectator fancies that there are often three or four real ſuns in the firmament at the ſame time. In this ſplendid appearance the real ſun is always readily known by its ſuperior brightneſs, every reflection being ſeen with diminiſhed ſplendour. The ſolar rainbow there is often ſeen different from

ours. Inſtead of a pleaſing variety of colours, it appears of a pale white, edged with a ſtripe of duſky yellow; the whole being reflected from the boſom of a frozen cloud.

But, of all the meteors which mock the imagination with an appearance of reality, thoſe ſtrange illuſions that are ſeen there, in fine ſerene weather, are the moſt extraordinary and entertaining. "Nothing," ſays Krantz, "ever ſurpriſed me more, than, on a fine warm ſummer's day, to perceive the iſlands that lie four leagues weſt of our ſhore, putting on a form quite different from what they are known to have. As I ſtood gazing upon them, they appeared, at firſt, infinitely greater than what they naturally are; and ſeemed as if I viewed them through a large magnifying glaſs. They were not thus only made larger, but brought nearer to me. I plainly deſcried every ſtone upon the land, and all the furrows filled with ice, as if I ſtood cloſe by. When this illuſion had laſted for a while, the proſpect ſeemed to break up, and a new ſcene of wonder to preſent itſelf. The iſlands ſeemed to travel to the ſhore, and repreſented a wood, or a tall cut hedge. The ſcene then ſhifted, and ſhewed the appearance of all ſorts of curious figures; as ſhips with ſails, ſtreamers, and flags; antique elevated caſtles, with decayed

turrets; and a thousand forms, for which fancy found a resemblance in nature. When the eye had been satisfied with gazing, the whole groupe of riches seemed to rise in air, and at length vanish into nothing. At such times the weather is quite serene and clear; but comprest with such subtle vapours, as it is in very hot weather; and these appearing between the eye and the object, give it all that variety of appearances which glasses of different refrangibilities would have done." Mr. Krantz observes, that commonly a couple of hours afterwards, a gentle west wind and a visible mist follows, which puts an end to this *lusus naturæ*.

It were easy to swell this catalogue of meteors with the names of many others, both in our own climate and in other parts of the world. Such as falling stars, which are thought to be no more than unctuous vapours, raised from the earth to small heights, and continuing to shine till that matter which first raised and supported them, being burnt out, they fall back again to the earth, with extinguished flame. Burning spears, which are a peculiar kind of aurora borealis; bloody rains, which are said to be the excrements of an insect, that at that time has been raised into the air. Showers of stones, fishes, and ivy-berries,

at firſt, no doubt, raiſed into the air by tem-peſts in one country, and falling at ſome con-ſiderable diſtance, in the manner of rain, to aſtoniſh another. But omitting theſe, of which we know little more than what is thus briefly mentioned, I will conclude this chapter with the deſcription of a water-ſpout; a moſt ſur-priſing phenomenon; not leſs dreadful to ma-riners, than aſtoniſhing to the obſerver of na-ture.

Theſe ſpouts are ſeen very commonly in the tropical ſeas, and ſometimes in our own. Thoſe ſeen by Tournefort, in the Mediter-ranean, he has deſcribed as follows. "The firſt of theſe," ſays this great botaniſt, "that we ſaw, was about a muſket-ſhot from our ſhip. There we perceived the water began to boil, and to riſe about a foot above its level. The water was agitated and whitiſh; and above its ſurface there ſeemed to ſtand a ſmoke, ſuch as might be imagined to come from wet ſtraw before it begins to blaze. It made a ſort of a murmuring ſound, like that of a torrent, heard at a diſtance, mixed, at the ſame time, with an hiſſing noiſe, like that of a ſerpent: ſhortly after we perceived a column of this ſmoke riſe up to the clouds, at the ſame time whirling about with great rapidity. It appeared to be

as thick as one's finger; and the former found still continued. When this disappeared, after lasting for about eight minutes, upon turning to the opposite quarter of the sky, we perceived another, which began in the manner of the former; presently after a third appeared in the west; and instantly beside it still another arose. The most distant of these three could not be above a musket-shot from the ship. They all continued like so many heaps of wet straw set on fire, that continued to smoke, and to make the same noise as before. We soon after perceived each, with its respective canal, mounting up in the clouds, and spreading where it touched; the cloud, like the mouth of a trumpet, making a figure, to express it intelligibly, as if the tail of an animal were pulled at one end by a weight. These canals were of a whitish colour, and so tinged, as I suppose, by the water which was contained in them; for, previous to this, they were apparently empty, and of the colour of transparent glass. These canals were not straight, but bent in some parts, and far from being perpendicular, but rising in their clouds with a very inclined ascent. But what is very particular, the cloud to which one of them was pointed happening to be driven by the wind, the spout still continued to follow its

motion, without being broken; and passing behind one of the others, the spouts crossed each other, in the form of a St. Andrew's cross. In the beginning they were all about as thick as one's finger, except at the top, where they were broader, and two of them disappeared; but shortly after, the last of the three encreased considerably; and its canal, which was at first so small, soon became as thick as a man's arm, then as his leg, and at last thicker than his whole body. We saw distinctly, through this transparent body, the water, which rose up with a kind of spiral motion; and it sometimes diminished a little of its thickness, and again resumed the same; sometimes widening at top, and sometimes at bottom; exactly resembling a gut filled with water, pressed with the fingers, to make the fluid rise, or fall; and I am well convinced, that this alteration in the spout was caused by the wind, which pressed the cloud, and impelled it to give up its contents. After some time its bulk was so diminished as to be no thicker than a man's arm again; and thus, swelling and diminishing, it at last became very small. In the end, I observed the sea which was raised about it to resume its level by degrees, and the end of the canal that touched it to become as small as if

it had been tied round with a cord; and this continued till the light, ſtriking through the cloud, took away the view. I ſtill, however, continued to look, expecting that its parts would join again, as I had before ſeen in one of the others, in which the ſpout was more than once broken, and yet again came together; but I was diſappointed, for the ſpout appeared no more."

Many have been the ſolutions offered for this ſurpriſing appearance. Mr. Buffon ſuppoſes the ſpout, here deſcribed, to proceed from the operation of fire, beneath the bed of the ſea; as the waters at the ſurface are thus ſeen agitated. However, the ſolution of Dr. Stuart is not diveſted of probability; who thinks it may be accounted for by ſuction, as in the application of a cupping-glaſs to the ſkin.

Wherever ſpouts of this kind are ſeen they are extremely dreaded by mariners; for if they happen to fall upon a ſhip they moſt commonly daſh it to the bottom. But, if the ſhip be large enough to ſuſtain the deluge, they are at leaſt ſure to deſtroy itt ſails and rigging, and render it unfit for ſailing. It is ſaid that veſſels of any force uſually fire their guns at them, loaden with a bar of iron; and, if ſo happy as to ſtrike them, the water is inſtantly ſeen to fall from them, with a dreadful noiſe, though without any further miſchief.

I am at a loſs whether we ought to reckon theſe ſpouts called typhons; which are ſometimes ſeen at land, of the ſame kind with thoſe ſo often deſcribed by mariners, at ſea, as they ſeem to differ in ſeveral reſpects. That, for inſtance, obſerved at Hatfield, in Yorkſhire, in 1687, as it is deſcribed by the perſon who ſaw it, ſeems rather to have been a whirlwind than a water-ſpout. The ſeaſon in which it appeared was very dry, the weather extremely hot, and the air very cloudy. After the wind had blown for ſome time, with conſiderable force, and condenſed the black clouds one upon another, a great whirling of the air enſued; upon which the center of the clouds, every now and then, darted down, in the ſhape of a thick long black pipe; in which the relator could diſtinctly view a motion, like that of a ſcrew, continually ſcrewing up to itſelf, as it were, whatever it happened to touch. In its progreſs it moved ſlowly over a grove of young trees, which it violently bent, in a circular motion. Going forward to a barn, it in a minute ſtript it of all the thatch, and filled the whole air with the ſame. As it came near the relator, he perceived that its blackneſs proceeded from a gyration of the clouds, by contrary winds, meeting in a point, or a center; and where the greateſt force was exerted, there

darting down, like an Archimedes's ſcrew, to ſuck up all that came in its way. Another which he ſaw, ſome time after, was attended with ſtill more terrible effects; levelling, or tearing up great oak trees, catching up the birds in its vortex, and daſhing them againſt the ground. In this manner it proceeded, with an audible whirling noiſe, like that of a mill; and, at length, diſſolved, after having done much miſchief.

But we muſt ſtill continue to ſuſpend our aſſent as to the nature even of theſe land ſpouts; ſince they have been ſometimes found to drop, in a great column of water, at once upon the earth, and produce an inſtant inundation*, which could not readily have happened had they been cauſed by the gyration of a whirlwind only. Indeed, every conjecture regarding theſe meteors, ſeems to me entirely unſatiſfactory. They ſometimes appear in the calmeſt weather at ſea, of which I have been an eye-witneſs; and, therefore, theſe are not cauſed by a whirlwind. They are always capped by a cloud; and, therefore, are not likely to proceed from fires at the bottom. They change place; and, therefore, ſuction ſeems impracticable. In ſhort, we ſtill want facts, upon which to build a rational theory; and, inſtead of know-

* Phil. Tranſ. vol. iv. p. 2. 108.

ledge, we must be contented with admiration. To be well acquainted with the appearances of Nature, even though we are ignorant of their causes, often constitutes the most useful wisdom.

CHAP. XXII.

The Conclusion.

HAVING thus gone through a particular description of the earth, let us now pause for a moment, to contemplate the great picture before us. The universe may be considered as the palace in which the Deity resides; and this earth as one of its apartments. In this, all the meaner races of animated nature mechanically obey him; and stand ready to execute his commands, without hesitation. Man alone is found refractory; he is the only being endued with a power of contradicting these mandates. The Deity was pleased to exert superior power in creating him a superior being; a being endued with a choice of good and evil; and capable, in some measure, of co-operating with his own intentions. Man, therefore, may be considered as a limited creature, endued with powers imitative of those residing in the Deity. He is thrown into a world that stands in need of his help; and has been granted a power of producing harmony from partial confusion.

If, therefore, we conſider the earth as allotted for our habitation, we ſhall find, that much has been given us to enjoy, and much to amend; that we have ample reaſons for our gratitude, and ſtill more for our induſtry. In thoſe great outlines of nature, to which art cannot reach, and where our greateſt efforts muſt have been ineffectual, God himſelf has finiſhed theſe with amazing grandeur and beauty. Our beneficent Father has conſidered theſe parts of nature as peculiarly his own; as parts which no creature could have ſkill or ſtrength to amend: and therefore, made them incapable of alteration, or of more perfect regularity. The heavens, and the firmament, ſhew the wiſdom, and the glory of the Workman. Aſtronomers, who are beſt ſkilled in the ſymmetry of ſyſtems, can find nothing there that they can alter for the better. God made theſe perfect, becauſe no ſubordinate being could correct their defects.

When, therefore, we ſurvey nature on this ſide, nothing can be more ſplendid, more correct, or amazing. We there behold a Deity reſiding in the midſt of an univerſe, infinitely extended every way, animating all, and cheering the vacuity with his preſence! We behold an immenſe and ſhapeleſs maſs of matter, formed into worlds by his power, and diſperſed at intervals, to which even the imagination cannot

travel! In this great theatre of his glory, a thousand suns, like our own, animate their respective systems, appearing and vanishing at divine command. We behold our own bright luminary, fixed in the center of its system, wheeling its planets in times proportioned to their distances, and at once dispensing light, heat, and action. The earth also is seen with its twofold motion; producing, by the one, the change of seasons; and, by the other, the grateful vicissitudes of day and night. With what silent magnificence is all this performed! with what seeming ease! The works of art are exerted with interrupted force; and their noisy progress discovers the obstructions they receive: but the earth, with a silent steady rotation, successively presents every part of its bosom to the sun; at once imbibing nourishment and light from that parent of vegetation and fertility.

But not only provisions of heat and light are thus supplied, but its whole surface is covered with a transparent atmosphere, that turns with its motion, and guards it from external injury. The rays of the sun are thus broken into a genial warmth; and, while the surface is assisted, a gentle heat is produced in the bowels of the earth, which contributes to cover it with verdure. Waters also are supplied in healthful

abundance, to ſupport life, and aſſiſt vegetation. Mountains ariſe, to diverſify the proſpect, and give a current to the ſtream. Seas extend from one continent to the other, repleniſhed with animals, that may be turned to human ſupport; and alſo ſerving to enrich the earth with a ſufficiency of vapour. Breezes fly along the ſurface of the fields, to promote health and vegetation. The coolneſs of the evening invites to reſt; and the freſhneſs of the morning renews for labour.

Such are the delights of the habitation that has been aſſigned to man; without any one of theſe, he muſt have been wretched; and none of theſe could his own induſtry have ſupplied. But while many of his wants are thus kindly furniſhed, on the one hand, there are numberleſs inconveniencies to excite his induſtry on the other. This habitation, though provided with all the conveniencies of air, paſturage, and water, is but a deſert place, without human cultivation. The loweſt animal finds more conveniencies in the wilds of nature, than he who boaſts himſelf their lord. The whirlwind, the inundation, and all the aſperities of the air, are peculiarly terrible to man, who knows their conſequences, and, at a diſtance, dreads their approach. The earth itſelf, where human art has not pervaded, puts on a frightful gloomy

appearance. The forests are dark and tangled; the meadows over-grown with rank weeds; and the brooks stray without a determined channel. Nature, that has been kind to every lower order of beings, has been quite neglectful with regard to him; to the savage uncontriving man the earth is an abode of desolation, where his shelter is insufficient, and his food precarious.

A world thus furnished with advantages on one side, and inconveniences on the other, is the proper abode of reason, is the fittest to exercise the industry of a free and a thinking creature. These evils, which art can remedy, and prescience guard against, are a proper call for the exertion of his faculties; and they tend still more to assimilate him to his Creator. God beholds, with pleasure, that being which he has made, converting the wretchedness of his natural situation into a theatre of triumph; bringing all the headlong tribes of nature into subjection to his will; and producing that order and uniformity upon earth, of which his own heavenly fabric is so bright an example.

END OF THE FIRST VOLUME.